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PHYCOLOGIA

OLUME 1 · NUMBER 1 · MARCH 1961

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UBLISHED QUARTERLY BY THE INTERNATIONAL PHYCOLOGICAL SOCIETY

INTERNATIONAL PHYCOLOGICAL SOCIETY

Dedicated to the promotion of phycology and to the encouragement of international cooperation among phycologists and phycological institutes.

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PHYCOLOGIA 1 (1) 1961

QK 564
P49
V. 1-3

The International Phycological Society

Editorial

The founding of the International Phycological Society is the outcome of a belief, shared by many of my colleagues, that the need for cooperation among phycologists of all nations is pressing to the point that it no longer can be ignored. The breath-taking advances of science and technology during recent years are like hurricane winds compared to the zephyrs of pre-World War II progress. The realm of scientific investigation has expanded in the direction of the infinitesimal on the one hand and the infinite on the other. The frontiers of thought have been swept far beyond many of us, and we may wonder whether our mental and physical resources are sufficient to permit us to cope with the demands of Space Age science.

Fortunately, the same factors that seemingly have made science more demanding help us meet these demands. Never before have we had such rich and varied resources to help us solve scientific problems and keep abreast of the times. And whether we apply old techniques to new material, new techniques to old material, or utilize newly gained physical and chemical information in devising still newer techniques, each of us will operate within his own sphere, in large part unaffected by the expansion of the scientific universe. Yet no one who recalls the time when he could read most research reports in *Science* or *Nature* with a satisfying degree of understanding would say that science as a profession has not changed. The number of investigators, laboratories, institutions, and even nations is increasing explosively. The rate at which we are accumulating data taxes the imagination, and the acceleration of this rate is so great as to give some credence to the prediction that progress in science will slowly grind to a halt unless ways and means are found to assimilate, integrate, correlate, and disseminate this staggering mass of data. Documentation of research must rely increasingly upon methods more economical and effective than those generally used today, and we shall find this aspect becoming farther removed from the hands of investigators and into those of specialized data processors.

All of us, even those farthest from the frontiers, thus face two serious problems: integration of ourselves into an ever-expanding community of scientists; and integration of our work into an ever-expanding body of scientific information. Help in solving both problems hopefully can be found in international cooperation, and fortunately the remarkably effective methods of transportation and communication make it feasible to associate ourselves in an international society. But international cooperation in science plays other, equally important rôles. In tackling major problems, we can overcome limitations of time, money, geography, and human resources by joining forces, whether this be at the level of the monographer who depends upon the kindness of his colleagues in supplying material from the far corners of the earth or at the grand scale of the International Geophysical Year. The preparation of annual phycological bibliographies, which has become a task of such magnitude that the collaboration of workers in several nations is required, is an example of a project within the immediate scope of our Society. Finally, international cooperation among scientists can make an important contribution toward winning world peace. Good will and understanding among individuals is the basis for good will and understanding among nations. Moreover, phycology can make important contributions to human welfare, and hence to peace, in such fields as public health and nutrition.

Examples of international cooperation in phycology include the highly successful sections of phycology of both the Paris (1954) and the Montreal (1959) botanical congresses and three seaweed symposia (Inveresk, 1952; Trondheim, 1955; Galway, 1958). These ventures contributed to an exchange of good will and ideas. Other programs are designed to carry out major research plans. Such a project is the program for the scientific exploration of the Indian Ocean sponsored by the International Council of Scientific Unions. By the conclusion of 1964, 15 nations ranging in size from Ceylon to the U.S.S.R. will have furnished 20 ships to conduct oceanographic studies of what is at present the least-known of the world's oceans. The sea floor, the crust of the earth beneath the sea, the ocean waters themselves, the plant and animal life in them, and the atmosphere over the ocean will be studied. Such investigations will form the groundwork of future efforts to exploit the food and other resources of the Indian Ocean to a fuller extent than at present. Simultaneously, in the eastern Pacific Ocean, another international research program is underway: a physical, chemical, and biological investigation of the Peru Current, sponsored by the National Science Foundation and Office of Naval Research (U.S.A.) and the Inter-American Tropical Tuna Commission. Oceanography has indeed been given a tremendous impetus by the recognition by governments of many nations that the oceans are a frontier at least as important as space. Hopefully, limnology and biological engineering will receive proper attention in the future.

In planning an international phycological society, it was suggested to the organizing committee, logically, that we consider the establishment of a federation of national societies. Arguments against this plan were twofold: first, only a few nations have societies; second, not all members of national societies are willing to support international activities. The obverse of the second point, namely, that certain persons are willing to support international but not national organizations, is substantiated by the results of our initial membership campaign. The existence of two levels of needs, problems, and activities – national and international – precludes the encroachment of one society upon another.

In setting the annual dues at one English pound ($ 2.80) we realize that the activities of the International Phycological Society, and more particularly the size of *Phycologia*, will be limited more than we wish; but the alternative – increasing the dues – would defeat the purpose of the organization by eliminating a large potential segment of our membership, for whom a pound is not a modest amount and two pounds would be prohibitive. Grants from government and industry will be sought to supplement the Society's income.

Phycologia is operated by and for the members of the International Phycological Society. It can be only as useful as members make it. Your contributions and support are essential. Your constructive criticisms will be appreciated and carefully considered. – PAUL C. SILVA.

The National Phycological Societies

(listed in order of founding)

Phycological Society of America

The "Phycological Society of the Americas," as it was originally called, was founded December 30, 1946, by a group of interested phycologists meeting in conjunction with the American Association for the Advancement of Science in Boston. The first issue of the *News Bulletin* was published in May 1947 under the editorship of G. W. PRESCOTT, to whom much credit should be given for the early success of the Society. The chief activity of the Society has been the sponsoring of annual paper-reading sessions and symposia, held in conjunction with conventions either of the A.A.A.S. or of the American Institute of Biological Sciences. Number of members (January 1, 1961): 327. Annual dues: $ 2.00. Officers (1960/1961): JACK MYERS, President; LUIGI PROVASOLI, Vice-President; WILLIAM A. DAILY, Secretary-Treasurer (Box 155, Butler University, Indianapolis 7, Indiana); JANET R. STEIN, Editor (Department of Biology and Botany, University of British Columbia, Vancouver 8, B.C., Canada).

British Phycological Society

As a result of a proposal originating from Dr. K. M. DREW BAKER and Dr. M. T. MARTIN, an informal meeting of phycologists was held at the University College of North Wales, Bangor, from 13th–20th September 1951. It was decided to hold further meetings as an informal group and to publish a news bulletin. The first issue of the *Phycological Bulletin* appeared in March 1952. (Beginning with No. 7, the title was changed to *British Phycological Bulletin.*) The Society was formally organized July 12, 1952, at a meeting of the British Phycological Group at the Department of Zoology, Edinburgh. The four main projects sponsored by the Society are: (1) the holding of scientific meetings; (2) the holding of field meetings; (3) the preparation of a revised check-list of the marine algae of the British Isles and the accumulation of information for an eventual comprehensive new British marine algal flora; (4) the publication of a news bulletin. Number of members (January 1, 1961): 145. Annual membership fee: £ 1. Officers of Council (1961): G. E. FOGG, President; R. W. BUTCHER and R. ROSS, Vice-Presidents; H. T. POWELL, Hon. Secretary (Marine Station, Millport, Isle of Cumbrae, Scotland, U.K.); M. T. MARTIN, Hon. Treasurer (University Hall, Bangor, Caernarvonshire, North Wales, U.K.). Hon. Editor of *British Phycological Bulletin* (1961): ELSIE CONWAY (Dept. of Botany, The University, Glasgow W.2., Scotland, U.K.). (Information kindly furnished by H. T. POWELL.)

Japanese Society of Phycology

The Society was founded November 11, 1952, by 35 promoters, including almost all senior Japanese phycologists. The objects of the Society are (1) to promote the development of phycology in Japan and (2) to further good fellowship among the people who have special interest in phycology. In order to attain these objects, the Society publishes *The Bulletin of Japanese Society of Phycology* (romanized Japanese title: *Sorui*), three numbers each year comprising one volume. It contains short original papers in Japanese (each with a summary in a European language) and notes on meetings, current literature, etc. Some short courses in phycology and occasional marine botanical field excursions are given under the auspices of the Society. Number of members (November 3, 1960): 339. Officers: Y. YAMADA, President; Y. NAKAMURA, S. SUTO, Y. SAKAI, S. FUNAHASHI, N. TAZAWA, and S. ENOMOTO, Secretaries. Office of Society: Department of Botany, Hokkaido University, Sapporo, Japan. (Information kindly furnished by Professor YAMADA.)

Société Phycologique de France

La Société, fondée le 21 février 1955, a pour objet de développer l'étude des Algues en France, de faciliter les relations scientifiques des phycologues français entre eux et avec leurs collègues étrangers et d'assurer la représentation officielle des phycologues français dans toutes les manifestations scientifiques internationales. La Société comprend actuellement une centaine de membres. Son Siège Social est au Laboratoire de Biologie végétale marine, 195 rue St. Jacques, Paris 5^{e}. Elle est administrée par un Conseil de 6 membres: M. G. DEFLANDRE, Mme G. FELDMANN, M. M. LEFÈVRE, Mme P. LEMOINE, M. F. MAGNE, M. E. MANGUIN; un secrétaire général, M. ADRIEN DAVY DE VIRVILLE; et une trésorière, Mlle C. ABELARD. La Société tient 3 ou 4 séances chaque année. Les communications sont publiées ou résumées dans le bulletin annuel qui publie également diverses informations susceptibles d'intéresser les phycologues. La Société organise également des excursions phycologiques ou des réunions d'études dans les laboratoires maritimes ou les stations d'hydrobiologie. Elle envisage de continuer la publication de l'exsiccata "Algues de France" commencée par G. HAMEL. – J. FELDMANN.

Algologická Sekce Československé Botanické Společnosti

The Phycology (Algology) Section of the Czechoslovak Botanical Society was founded in 1955 and associates those members of the Society who are active in algological work. The aim of the Phycology Section is to promote all kinds of algological research, especially on the flora of Czechoslovakia. Toward this goal, investigations of algologically interesting areas (e.g., High Tatra, peat bogs and ponds in South Bohemia) are organized and carried out in the field by groups of workers, specialized in different branches of phycology. The results will serve for the compilation of an Algal Flora of Czechoslovakia. Results of algological research in Czechoslovakia are published in *Preslia* (Journal of the Czechoslovak Botanical Society) or in other periodicals. Number of members: 31. Officers: Prof. Dr. BOHUSLAV FOTT, President; Dr. JIŘÍ RŮŽIČKA, Secretary. Office of Phycology Section: Benátská 2, Praha 2, Czechoslovakia. – B. FOTT.

Phycological Society of the Philippines

The activities of the Society, which was founded June 9, 1956, include the following: (1) Quarterly scientific meetings. (2) Creation of Subcommittees for the purpose of encouraging different fields of study: Taxonomy and Ecology (JOSE S. DOMANTAY, chairman); Physiology and Algal Culture (HERMINIO R. RABANAL, chairman); Algal Chemistry and Nutrition (ANTONIO I. DE LEON, chairman); Economics of Algae (DEOGRACIAS V. VILLADOLID, chairman); Medicine, Microbiology and Antibiotics (ROGELIO N. RELOVA, chairman); Public Relations (ZENON R. TORRES, chairman). (3) Cooperating with the Subcommittee on Algae of the Pacific Science Association by furnishing information on projects and research in progress. Number of members: 64. Officers: GREGORIO

T. Velasquez, President; Jose S. Domantay, Vice-President; Ernesta C. Galutira, Secretary-Treasurer (Botany Discipline, College of Arts and Sciences, University of the Philippines, Quezon City, Philippines). (Information kindly furnished by Dr. Velasquez.)

Phycological Society of India

The Society was founded at a meeting of Indian phycologists held under the chairmanship of Dr. M. S. Randhawa at New Delhi, December 11, 1959. The objects of the Society are to promote the study of phycology, to facilitate exchange between phycologists, and to publish a journal. Officers: M. O. P. Iyengar, President; M. S. Randhawa, Vice-President; G. S. Venkataraman, Secretary (Algal Laboratory, Indian Agricultural Research Institute, New Delhi-12, India); K. R. Ramanathan, Treasurer; T. V. Desikachary, Chief Editor (University Botany Laboratory, Triplicane, Madras-5, India). Annual individual subscription: Rs. 10/- plus entrance fee Rs. 5/- (Indian); U.S. $ 2.50 plus entrance fee $ 0.50 or 17s 6d plus 3s 6d (foreign). (Information furnished by organizational letter and by Dr. Desikachary.)

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The Structure and Reproduction of *Caloglossa leprieurii*

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University of California, Berkeley, U. S. A.

Abstract

The costate, ribbon-like axes of *Caloglossa leprieurii* have a dome-shaped apical cell, which by transverse division cuts off segments posteriorly. Each segment cell undergoes division into a central cell and four pericentral cells. The two lateral pericentral cells are produced before the two transverse pericentral cells, and in the usual delesseriaceous fashion give rise to lateral rows of cells which form the monostromatic wings of the thallus. The axes are monopodial and the primary, apically (exogenously) produced branches are alternately arranged on the axes. Secondary, endogenously produced branches are also formed. One such branch usually develops at each node and usually emerges on the dorsal (upper) surface of the thallus. Occasionally, an endogenously produced branch also issues from the midrib of an internode. At the nodes are also formed rhizoids which are usually initiated by the ventral (lower) pericentral cells. The sexual plants are usually dioecious, but in rare instances they are monoecious. The spermatangia are formed in sori which develop on the wings of the thallus on both sides of the midrib and simultaneously on both surfaces of the terminal and subterminal internodes. Procarps are produced in acropetal succession by the transverse pericentral cells in the terminal parts of the thallus. Generally, they are formed on the ventral surface, but not infrequently they also occur on the dorsal surface, and at times they are produced on both surfaces of an internode. In general, the development of the procarp and cystocarp is like that in other Delesseriaceae. However, the carpogonium of *Caloglossa* forms a connecting cell. This is a primitive feature which heretofore has not been observed in any of the many genera of Delesseriaceae that have been studied. The tetrasporangia are generally produced in the tips of the tetrasporophytes. The sporangia are formed by the cells of the wings of the thallus. Each cell forms only one sporangium. After the sporangium has been initiated, the remaining portion of the mother cell divides by two periclinal walls to form a cover cell on each surface. The present study supports Kylin's placement of *Caloglossa* in a separate group within the Delesseriaceae. *Taenioma* is here removed from the *Sarcomenia* to the *Caloglossa* group. The question of the systematic position of the *Sarcomenia* group (which was recently transferred to the Rhodomelaceae by Womersley and Shepley) is discussed in some detail. It is concluded that it would be incorrect to place the members of this group anywhere else than in the Delesseriaceae, where they occupy a position seemingly not far removed from the *Claudea* and *Caloglossa* groups.

Introduction

Caloglossa (HARVEY) J. AGARDH (1876) is the most widely distributed genus of Delesseriaceae. Its type species, *C. leprieurii*, is more or less cosmopolitan in the tropics, with extensions into temperate regions in eastern North America and Japan in the northern hemisphere and to South Africa, Tasmania and New Zealand in the southern hemisphere (POST, 1943). Despite this wide distribution very little is known about the development of the sexual reproductive organs and the cystocarp in *Caloglossa*.

This gap in knowledge is owing, no doubt, to the relatively rare occurrence of sexual reproductive organs, as is evident from the data furnished by POST (1957) on the places where and dates on which fertile material of the six species of the genus has been obtained. Several authors have made incidental reference to the cystocarp, but only CRAMER (1891) studied this structure, and his work was very incomplete. Nothing is known about the ontogeny of the procarp. Limited observations on the development of the spermatangia were made by CRAMER (1891).

The present study is based on female, male and tetrasporangial material that Dr. MARY A. POCOCK and I collected about half a mile upstream from the mouth of the Umzimvubu River at Port St. Johns, South Africa, on August 1, 1938. Both fixed (KARPETCHENKO's solution) and formalin-preserved material was used. This material has been determined by POST (1939, p. 32) as forma *leprieurii* (her f. *typica*) of *Caloglossa leprieurii*.

Structure of the Thallus

Caloglossa leprieurii has a costate, ribbon-like, more or less dichotomously branched thallus (Figs. 1, 2). Actually, as was first pointed out by NÄGELI (1855), the axes are monopodial and the primary, apically produced, branches are alternately arranged on the axes. All axes are of the indeterminate kind. In addition to the primary branches, which are exogenous in origin, endogenously produced branches are also formed. One such branch is usually formed at each node and it usually emerges on the dorsal surface of the thallus (Fig. 1). Occasionally, an endogenously produced branch also issues from the midrib of an internode (Fig. 1). At the nodes are also produced rhizoids which arise from the ventral surface of the thallus (Fig. 2).

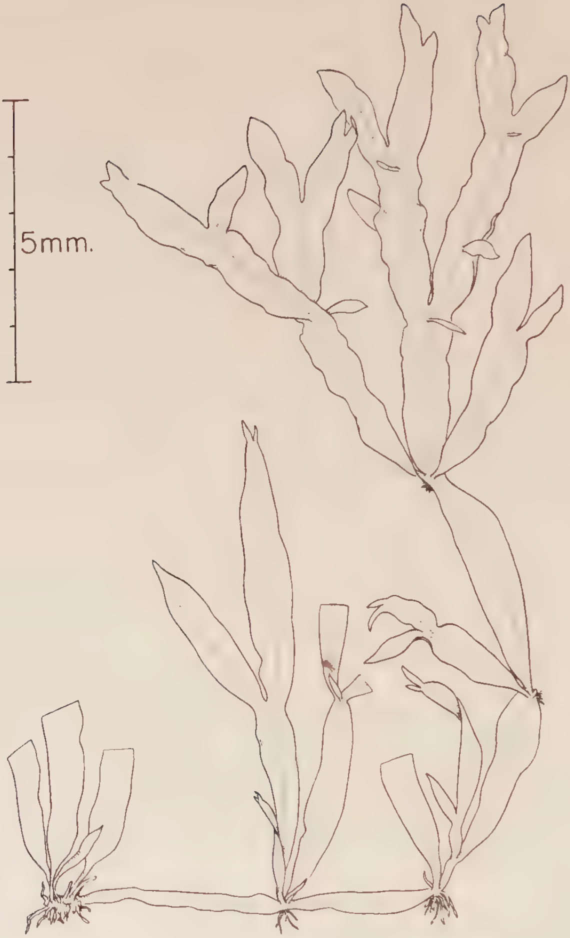


Fig. 1. *Caloglossa leprieurii*. Habit of plant.

The ontogeny of the thallus of *Caloglossa leprieurii* has been studied by several workers (NÄGELI, 1855; CRAMER, 1891; POST, 1943; FAN, 1952). A brief description consequently will suffice.

The dome-shaped apical cell by transverse division cuts off segments posteriorly (Fig. 3). The segment cells soon divide by two longitudinal walls at right angles to the flat surface of the thallus to produce a lateral pericentral cell on each side of the remaining central cell. Next the central cell cuts off, by periclinal divisions, a transverse pericentral cell on each of the two surfaces. The upper (dorsal) pericentral cell is usually formed before the lower (ventral) pericentral cell (Fig. 4). Two or more segments usually intervene between the completion of lateral pericentral cell

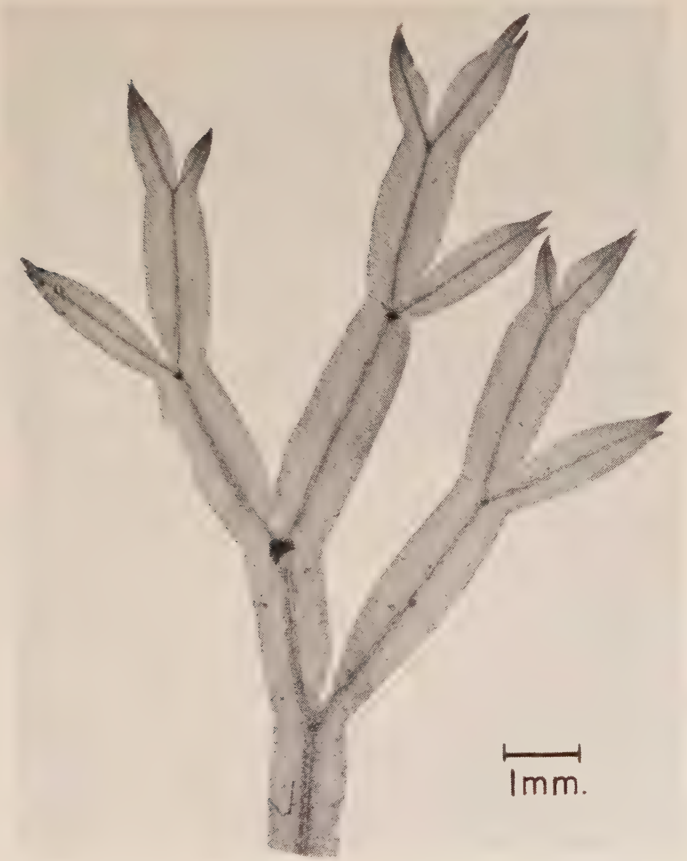


Fig. 2. *Caloglossa leprieurii.* Ventral surface of terminal part of thallus, showing clusters of young rhizoids at the nodes.

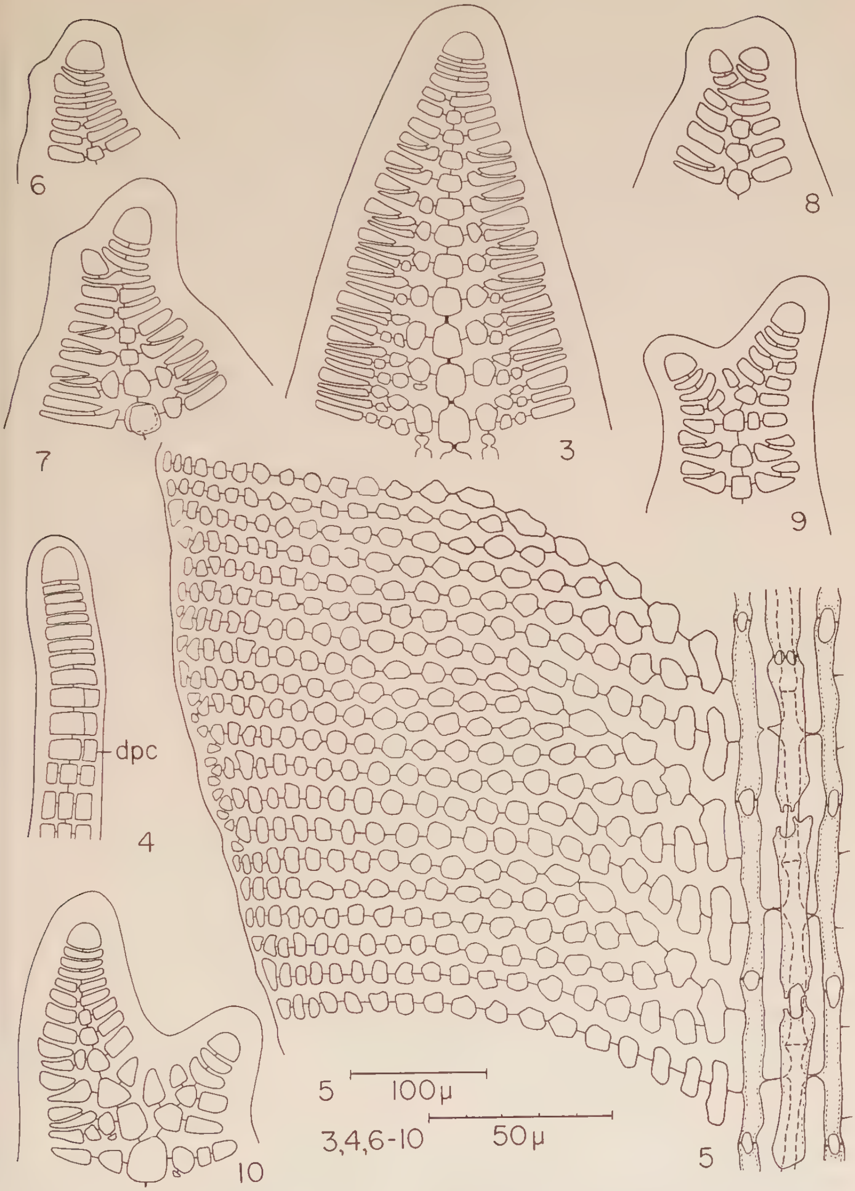
formation and the onset of transverse pericentral cell formation. The transverse pericentral cells ordinarily undergo no division in either the vertical or the horizontal plane (except for the formation of secondary pit connection cells), so the thallus remains three cells thick in the central cell or midrib region. The lateral pericentral cells in the usual delesseriaceous fashion behave as lateral initials (KYLIN, 1923, pp. 67–69, 81–82) and through division produce the wings of the thallus (Fig. 3). In the vegetative condition the wings remain monostromatic.

The mature frond is composed basically of three orders of cells. Only at the margins are a few cells of the fourth order produced (Fig. 5). Each of the first-formed cells of the second order functions as an initial and produces a cell row of the third order toward the proximal end of the blade and all the lateral initials lie at the margin of the thallus (Figs. 3, 5). There may be as many as six cell rows of the third order (Fig. 5). No intercalary cell divisions occur in the thallus of *Caloglossa leprieurii*. Secondary pit connections are abundantly formed by all the cells of the frond except the central cells, which do not form them. (In Figure 5 the secondary pit connections between the pericentral cells are indicated, but they are omitted from the cells of the wing in order to show clearly the cell lineages in the formation of the wing of the thallus. At the lower end of Figure 10 are shown two small pit connection cells that have just been cut off from lateral pericentral cells and in the lower end of Figure 3 are shown two secondary pit connections that have been established between lateral pericentral cells.)

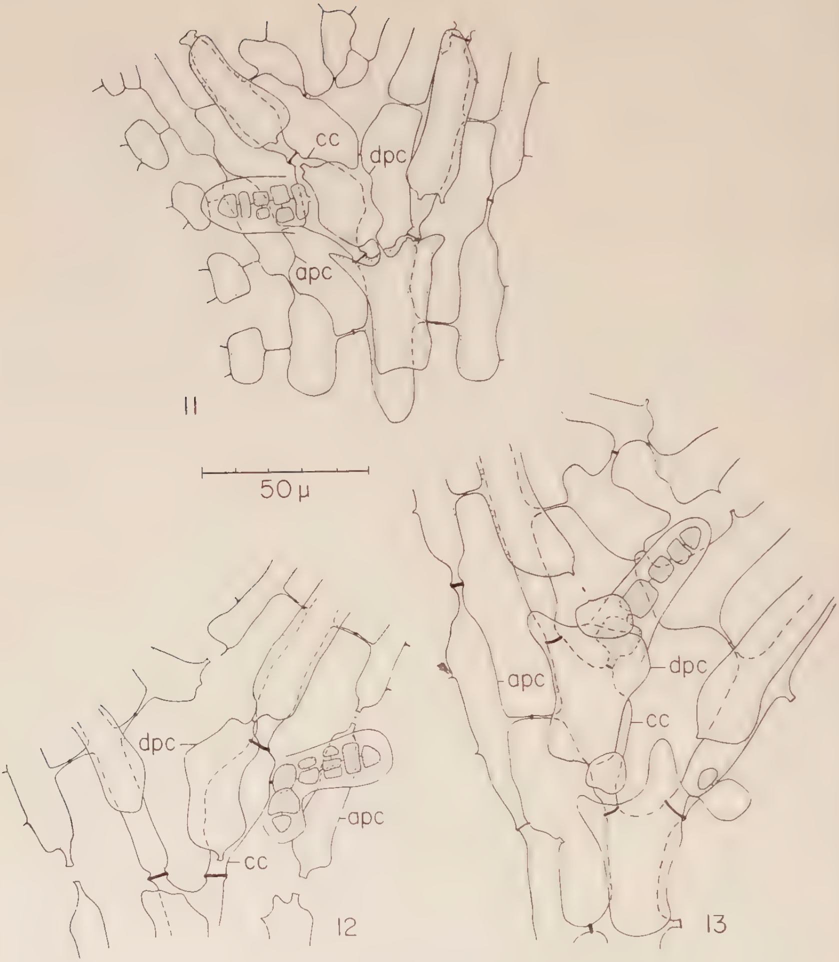
The primary branches of the thallus are exogenous in origin, as was first shown by Nägeli (1855). When a branch is to be initiated, the apical cell (which ordinarily divides by transverse septa) divides by an oblique wall cutting out a segment which is higher on one side than on the other. Through enlargement the higher side forms a protuberance (Fig. 6) which is cut off (Fig. 7). The cell so formed is a branch initial and divides in the usual transverse fashion (Figs. 8, 9). The basal segment of a branch does not form a lateral pericentral cell on its adaxial side (Fig. 10). This feature makes it possible to distinguish a branch from the main axis even in old parts of the thallus. As has been mentioned above, the axis is monopodial and the primary branches are produced at irregular intervals in alternate sequence. Nägeli (1855) observed that there may be an interspace of 14 to 45 segment cells between branches; but at times the branches are less than 14 segment cells apart, as was also observed by Cramer (1891). From older stages the impression is gained that the branches in *Caloglossa leprieurii* are marginal in position (and they have been so referred to in some of the literature), but examination of their method of initiation clearly reveals their exogenous origin. In method of branch initiation and branch arrangement *Caloglossa* thus agrees with *Taenioma* (Papenfuss, 1944).

Not infrequently, as shown in Figure 10, a branch may develop more vigorously than the main axis and assume the lead. Congenital fusion occurs at the base of a branch and the adjacent part of the main axis through the establishment of secondary pit connections between the adjoining marginal cells, and in this way the branch becomes securely fastened to the axis.

In addition to the exogenously formed primary branches, endogenously formed secondary branches are also produced. Characteristically, they are formed at the nodes, but they may also occur on the midrib of an



Figs. 3–10. *Caloglossa leprieurii*. Figs. 3–5. Stages in the development of the thallus; Figs. 3, 5 are surface views, Fig. 4 is a median longitudinal section through a young tip, showing at the lower end central cells and transverse pericentral cells: *dpc*, dorsal pericentral cell. In Fig. 3 the transverse pericentral cells are not indicated and in Fig. 5 only one of the two series of transverse pericentral cells is indicated and all secondary pit connections have been omitted, except those between adjoining pericentral cells. Figs. 6–10. Stages in the initiation and development of apically (exogenously) produced branches. In Fig. 10 the branch (on the left) has developed more vigorously than the main axis and is assuming the lead.



Figs. 11–13. *Caloglossa leprieurii*. Stages in early development of endogenously formed nodal branches: *cc*, central cell; *dpc*, dorsal pericentral cell; *apc*, abaxial pericentral cell.

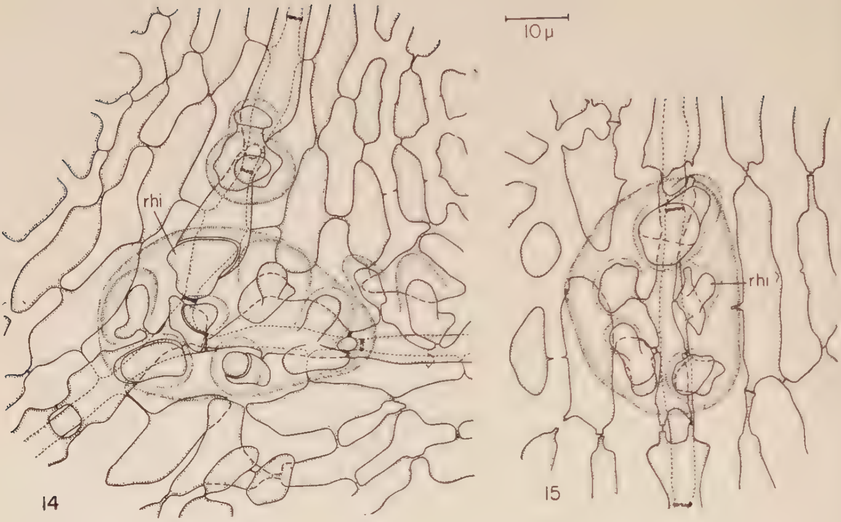
internode (Fig. 1). In both instances, the branch is initiated by the subterminal region of a central cell.

The nodal branches are usually initiated at a stage when the node is only two internodes behind the apex of the thallus. The branch is usually produced by the central cell of the basal segment of the primary branch and only rarely by the central cell of the main axis. The central cell forms a subterminal protuberance, usually on its abaxial side and toward the dorsal surface of the thallus. Later, the protuberance is cut off by a curved wall. The cell so formed is the branch initial, and it divides to produce a branch which emerges between the abaxial (lateral) and dorsal pericentral cells of the parent branch (Fig. 11). At times the branch initial is produced on the adaxial side of the central cell (Fig. 13). The basal segment of the branch forms one or two pericentral cells — never, apparently, the full complement of four pericentral cells. Secondary pit connections are subsequently established between the cells of the branch and those of the mother branch. Not infrequently the young branch forms a branch of a higher order at its base (Fig. 12). The majority of nodal branches emerge on the dorsal surface of the thallus, but occasionally they emerge on the ventral surface. It is of interest to note that FAN (1952, p. 8, fig. 15) observed that at times two endogenous branches are produced by a central cell immediately above a node in *Caloglossa leprieurii*. This condition was not observed in the present study of this species. It should also be noted that in some species of *Caloglossa*, for example *C. bombayensis* and *C. ogasawaraensis*, branches may be produced from marginal cells of the thallus (FAN, 1952, figs. 17–20 and 21–22, respectively). Marginally produced branches do not occur in *C. leprieurii*. Of special interest is the fact that endogenous branches are not produced in *C. bombayensis* and *C. ogasawaraensis* (FAN, 1952).

The endogenous branches occasionally formed on the midrib of an internode in *Caloglossa leprieurii* usually emerge on the dorsal surface between the dorsal and one of the lateral pericentral cells of the segment in question. The basal segment or two of these branches do not form pericentral cells. The branch becomes firmly anchored to the parent axis by means of secondary pit connections that are established between its basal cells (excluding the central cells, however) and the cells of the parent axis. Endogenous branches may at times also be produced on the ventral surface of the midrib (Fig. 1), as was also observed by CRAMER (1891).

In the basal segments of endogenous branches, flanking cell formation is less extensive than in exogenous branches and, as a result, such branches are stipitate (Fig. 1).

In addition to the primary rhizoids produced at the basal end of the sporeling (cf. illustrations of POST, 1957), clusters of rhizoids are regularly formed at the nodes (Figs. 2, 14) and usually on the ventral surface. The rhizoids are usually produced by the ventral (transverse) pericentral cell of the segment which produced an exogenous branch and by the ventral pericentral cells of one or two of the segments of both the branch and the main axis immediately above the bifurcation (Fig. 14). Usually only three transverse pericentral cells are involved in rhizoid formation. At times



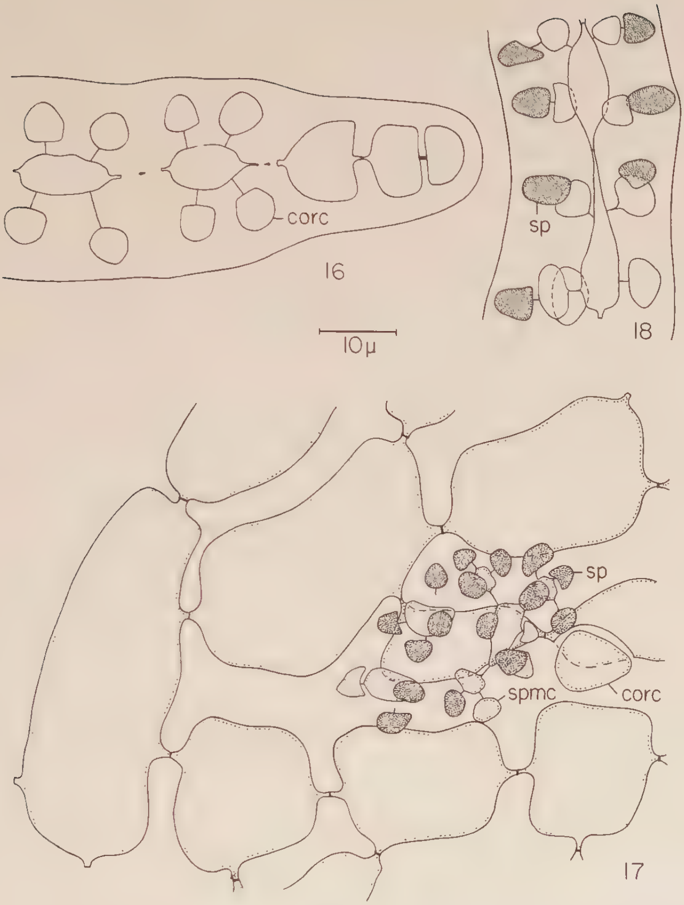
Figs. 14–15. *Caloglossa leprieurii.*
Formation of nodal (Fig. 14) and internodal (Fig. 15) rhizoids by ventral pericentral cells: *rhi*, rhizoid initial.

the lateral pericentral cells in the nodal region also produce rhizoids and occasionally they may be formed by the dorsal pericentral cells in the nodal region. Each pericentral cell produces from one to five rhizoid initials. They arise as papilla-like outgrowths on the surface and the lateral sides of the pericentral cells. The protuberance is next cut off by a concave wall and the initial so formed gives rise to a septate rhizoid. The rhizoids are simple in the proximal region, but as elongation advances they become weakly branched. They usually terminate in a digitate attachment organ (cf. also Post, 1943, fig. 37).

Rhizoids are occasionally also formed on the internodes (Fig. 15). In such instances they are also initiated by the ventral pericentral cells and their development is like that of the nodal rhizoids. The production of rhizoids by marginal cells of the thallus, such as Post (1943, fig. 38) illustrated for *Caloglossa adnata*, was not observed in *C. leprieurii*.

Development of Spermatangia

The sexual plants are usually dioecious, but in rare instances they are monoecious. The spermatangia are formed in sori which develop on the wings of the thallus on both sides of the midrib and simultaneously on



Figs. 16–18. *Caloglossa leprieurii*. Stages in development of spermatangia. Fig. 16. Formation of cortical cells by primary cells as seen in section through fertile area. Figs. 17, 18. Spermatangial mother cells and spermatangia as seen in surface view (Fig. 17) and in section through soral area (Fig. 18): *corc*, cortical cell; *spmc*, spermatangial mother cell; *sp*, spermatangium.

both surfaces of the terminal and subterminal internodes. At maturity the sori may cover the fertile parts except for two or more cell rows on either side of the midrib and at least one cell row (usually two or more) along the margins. Not infrequently, however, an entire lateral cell row may also remain sterile.

The first step in the production of spermatangia is the formation of cortical cells. Two to four, usually two or three, cortical cells are cut out by concave walls on each surface of the fertile primary cell (Figs. 16, 17). The cortical cells themselves may serve as spermatangial mother cells or they may divide by anticlinal walls to form from two to seven spermatangial mother cells (Fig. 17). Each spermatangial mother cell forms from one to three protuberances toward the outer surface. These are cut out by anticlinal concave walls and develop into spermatangia (Figs. 18, 17).

The method of cortical cell formation in preparation for spermatangial production in *Caloglossa leprieurii* is like that described by WOMERSLEY and SHEPLEY (1959) for *Sarcomenia delesserioides, Platysiphonia victoriae* and *P. corymbosa*, and is different from that described for other monostromatic Delesseriaceae or genera in which the spermatangial blades are still monostromatic when spermatangium formation commences. In genera of the latter type each primary cell characteristically forms, by two periclinal divisions, a single cortical cell on each surface. The cortical cells then divide by anticlinal walls to produce spermatangial mother cells. Deviations from these two methods are presented by *P. parva* and *P. miniata*. In *P. parva*, according to SILVA and CLEARY (1954), the lateral pericentral cells by periclinal division form a cortical cell on each surface, as in most monostromatic Delesseriaceae. The cells flanking the pericentral cells, however, divide only once periclinally, and in these parts no residual cells are present. In the material of *P. miniata* studied by WOMERSLEY and SHEPLEY, the lateral pericentral cells as well as the flanking cells divide only once periclinally.

In SILVA and CLEARY's figure 25 a, however, as many as three cortical cells are shown connected to one surface of a residual cell. It seems likely, therefore, that in *Platysiphonia parva* the lateral pericentral cells may form more than one cortical cell on each surface and in this respect there is agreement with *Caloglossa leprieurii* rather than with the majority of monostromatic Delesseriaceae*).

Development of the Procarp and Cystocarp

Procarps are formed in acropetal succession by the transverse pericentral cells in the terminal parts of the thallus. Generally, they are produced on the ventral surface, but not infrequently they are also formed on the dorsal surface and at times they are formed on both surfaces of the same internode. CRAMER (1891) observed them to occur exclusively on the ventral surface, as far as he was able to identify the surface with certainty. POST (1943, p. 175) also observed them to be confined to the ventral surface. In referring to CRAMER's observations in an earlier paper (PAPENFUSS, 1937, p. 60), I stated that he observed cystocarps to arise only from the dorsal surface. This was a false homologization of the condition in *Caloglossa* with that in *Claudea* and *Vanvoorstia* in which the upper (adaxial) surface was designated by me as ventral and the lower (abaxial) surface as dorsal. In prostrate forms such as *Caloglossa leprieurii*, the upper and lower surfaces are customarily referred to as dorsal and ventral, respectively.

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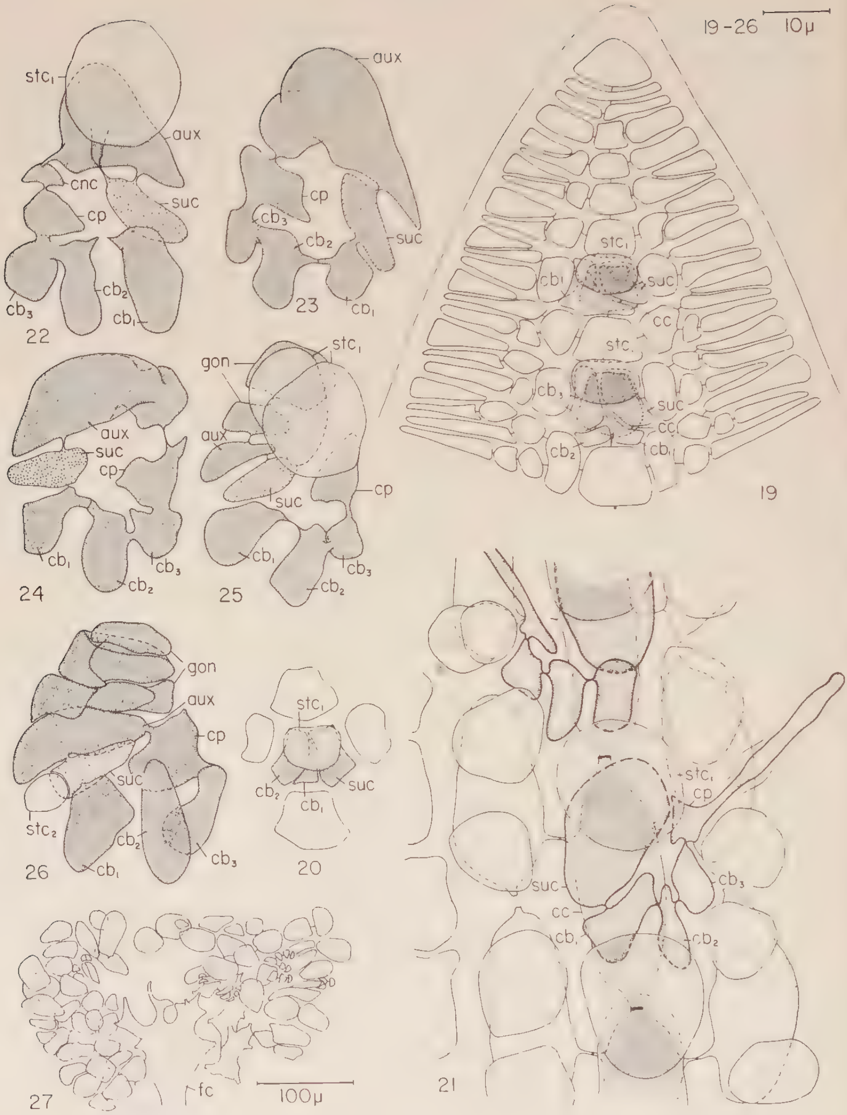
*) Dr. SILVA has restudied the preparation from which fig. 25 a was drawn and agrees with the present interpretation.

The fertile pericentral cell by a concave wall first cuts out a cover cell (mother cell of sterile group one) toward the apex of the axis. The pericentral cell, or supporting cell as it is called from then on, next divides by a vertical concave wall to cut off on one of its lateral sides the carpogonial branch initial (Fig. 19, the upper procarp). This initial gives rise, in acropetal succession, to a four-celled carpogonial branch (Figs. 19–21) which is directed toward the apex of the axis, with the carpogonium occupying a position lateral to the terminal end of the supporting cell (Fig. 21). The full grown trichogyne projects obliquely toward the tip of the axis (Fig. 21) and extends outward beyond the gelatinous matrix of the thallus. Rarely, it emerges on the opposite surface of the frond. Previous to fertilization the procarp thus consists of the supporting cell, the mother cell of the first group of sterile cells, and a four-celled carpogonial branch.

A fertile apex usually contains from five to seven or more young procarps and they often occur on consecutive segments. As in *Claudea multifida* and *Vanvoorstia spectabilis* (PAPENFUSS, 1937), *Platysiphonia parva* (SILVA and CLEARY, 1954), and *Sarcomenia delesserioides*, *Platysiphonia victoriae*, *P. corymbosa*, *P. miniata*, *Sarcotrichia tenera* and *S. dolichocystidea* (WOMERSLEY and SHEPLEY, 1959), only one of the transverse pericentral cells of a segment forms a procarp. The carpogonial branches in consecutive segments usually diverge to the right and left of the supporting cell in alternating sequence (Fig. 21) as in other Delesserioideae, but irregularities frequently occur. If a procarp is fertilized, the other procarps in that apex usually cease further development. This is not always so, however, for occasionally two cystocarps occur on the same internode – both on the same surface or one on each surface. Even before fertilization has occurred, cortication of the lateral pericentral cells of a fertile segment commences.



Figs. 19–27. *Caloglossa leprieurii.* Stages in development of procarp (Figs. 19–24) and gonimoblast (Figs. 25–27): *cc*, central cell; *suc*, supporting cell; stc_1, sterile cell group one; stc_2, sterile cell group two; *cbi*, carpogonial branch initial; cb_1, cb_2, cb_3, first, second and third cell of carpogonial branch, respectively; *cp*, carpogonium; *aux*, auxiliary cell; *cnc*, connecting cell; *gon*, gonimoblast; *fc*, fusion cell.

After fertilization of a carpogonium has taken place, the supporting cell may cut off a second sterile cell, the mother cell of sterile cell group two. This cell is cut off from the basal part of the supporting cell. It may divide once, but owing to its rare occurrence, it was not determined whether the division takes place before or after the formation of the auxiliary cell or the early stages in the development of the gonimoblast. Two cells appear to be the maximum number of cells produced in sterile cell group two. Not infrequently sterile group two is not produced or, if produced, it remains a single cell (Fig. 26).

Sterile group one usually remains a single cell, but in rare instances the mother cell divides once after fertilization has occurred (Fig. 25). The total number of sterile cells produced apparently does not exceed four, but usually there are fewer, and at times apparently only one sterile cell is formed, the mother cell of the first sterile group.

After fertilization, both the carpogonium and the supporting cell enlarge. The supporting cell next divides by a vertical wall which is diagonal to the longitudinal axis of the frond. The cell so formed is the auxiliary cell. One of its ends is usually directed toward and close to the carpogonium. Soon afterward the carpogonium cuts off a connecting cell on the side facing the auxiliary cell (Fig. 22). This cell fuses with the auxiliary cell (Figs. 23, 24) and presumably delivers to it a diploid nucleus. Sometimes the auxiliary cell sends out a process which meets the connecting cell (Fig. 22). To judge from the examples seen of this stage, it seems that the connecting cell always completely coalesces with the auxiliary cell (Figs. 23, 24). During the development of the gonimoblast, the pit connection between the carpogonium and the former connecting cell may be broken (Fig. 25). At times, however, it is still intact in advanced stages of the young gonimoblast (Fig. 26).

The primary gonimoblast cell is cut off from the end of the auxiliary cell which is directed toward the tip of the fertile axis. This cell functions as an initial and through division forms a short row of cells (Fig. 25). These cells then divide in several planes to produce the gonimoblast (Fig. 26). During the development of the gonimoblast, a fusion cell is produced at its base (Fig. 27). Presumably, this cell is formed as in other Delesseriaceae by the fusion of the fertile central cell, the supporting cell, the auxiliary cell and some of the basal cells of the gonimoblast, but this was not confirmed in this study. In older stages, most of the cells of the gonimoblast are converted into carposporangia (Fig. 27). New aggregations of gonimoblast cells are, however, formed between the older cells (Fig. 27), and in this way more than one crop of carposporangia is produced.

Even before fertilization, the lateral pericentral cells of the fertile segment begin to form cortical cells (Fig. 21). Following fertilization, cortication is accelerated and also extends to the cells flanking the pericentral cells. Eight to ten filaments are thus produced which grow over the developing gonimoblast and constitute the cystocarpic wall. The filaments do not meet at the summit of the cystocarp and the resulting circular opening is the ostiole. At the base of the cystocarp the wall is composed of several layers of cells. Farther up, the wall consists of two layers of cells, the outer of which is formed by periclinal division of the cells of the pericarpic filaments. Short rows of cortical cells are also formed on the surface opposite the floor of the cystocarp.

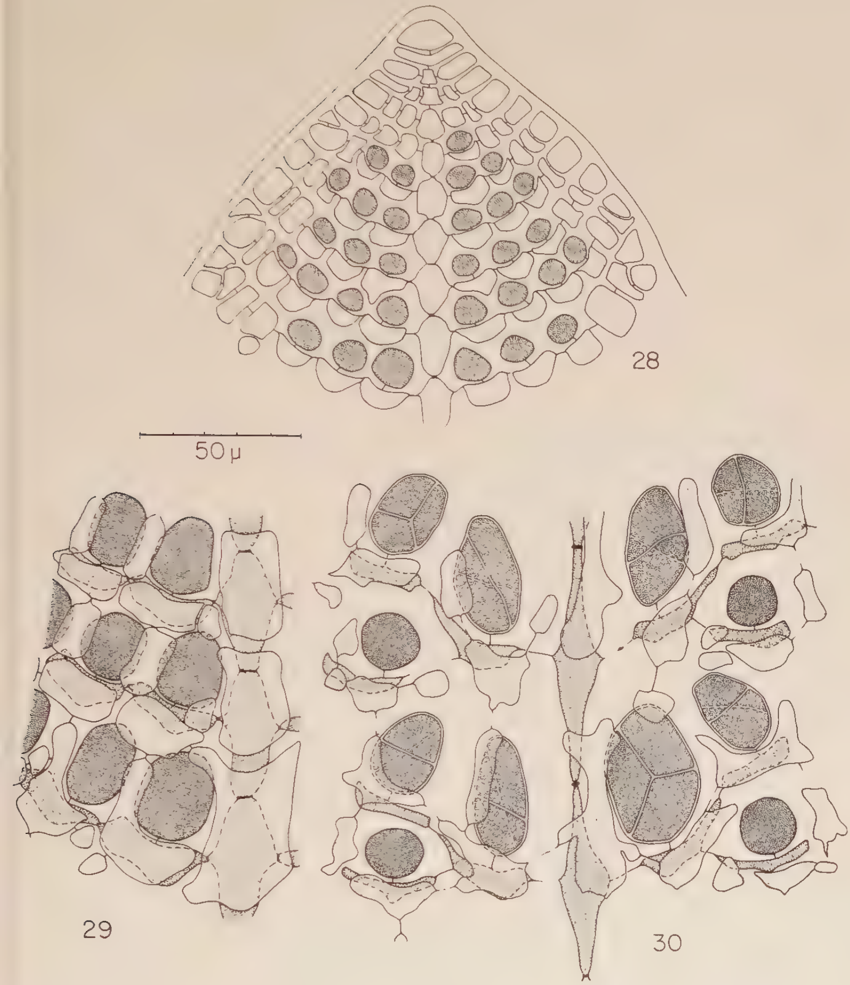
Development of Tetrasporangia

Observations on the tetrasporangia of *Caloglossa* have been made by a number of investigators (cf. Post, 1957, pp. 105, 114–117). In *C. leprieurii*, tetrasporangia are generally produced in the tips of the tetrasporophytes. Usually it is the terminal and subterminal internodes that become fertile. Post (1943, pp. 178–179) has observed instances of the occurrence of cystocarps and tetrasporangia on the same plant of *Caloglossa*.

The sporangia are formed by any of the cells of the wings of the thallus except for two or more of the rows of cells along the margins (Fig. 28). Formation of sporangia takes place in acropetal succession and from the lateral pericentral cells toward the margins of the blade. The sporangia produced by the two lateral pericentral cells of a segment are thus in a more advanced stage of development than those formed by the cells flanking them and by the lateral pericentral cells of the segment immediately in front (Fig. 28).

In the tips of sporangium-forming axes, the division of the lateral pericentral cells in the process of wing formation is different from that in the tips of vegetative and sexual plants. Instead of dividing by diagonal walls, the initials of the second order divide by transverse walls. The result is that no cell rows of the third order are formed (Fig. 28) except along the margin of the blade.

The sporangia are cut off by a vertical concave wall from the anteriorly directed sides of the cells (Fig. 28). Each cell forms only one sporangium. After the sporangium has been initiated, the remaining portion of the primary cell, now referred to as the stalk cell, divides by two periclinal



Figs. 28–30. *Caloglossa leprieurii.* Stages in initiation and development of tetrasporangia as seen in surface view of sorus. In Fig. 28 the transverse pericentral cells and cover cells present in the lower part of the branch tip are not indicated.

walls to form a cover cell on each surface. The cover cells soon enlarge and divide and the cells so formed establish secondary pit connections with similarly-formed neighboring cells. In this way a reticulate covering is formed over the sporangia (Figs. 29, 30). However, this covering never completely covers the enlarging sporangia, which, consequently, in the mature condition, always remain partially exposed on both surfaces. No differences exist in the degree of covering on the two surfaces. The four spores of a sporangium are tetrahedrally arranged.

Discussion

The genus *Caloglossa* has, since its establishment, been placed in the family Delesseriaceae of the order Ceramiales, a position confirmed by the results of the present study. In recent times, discussion has centered on the question of the more immediate affinities of the genus. In 1937 I placed *Caloglossa* near *Claudea* and *Vanvoorstia* in the then newly established *Claudea* group on the basis of several features which these three genera share. Later (1944), I removed *Caloglossa* from the *Claudea* group and suggested its close relationship to *Taenioma*, a genus generally placed in the *Sarcomenia* group. A group to include these two genera was not formally proposed, however, pending additional knowledge. In 1956 KYLIN retained *Taenioma* in the *Sarcomenia* group but (p. 427) placed *Caloglossa* in its own group, characterized by the following features: (1) all tertiary initials lie at the margin of the thallus; (2) intercalary cell divisions are lacking; (3) carposporangia are formed in chains; (4) tetrasporangia are produced by primary cells; and (5) branches issue from the margin of the thallus.

In my opinion the *Caloglossa* group merits recognition. It is desirable, however, to modify KYLIN's characterization with reference to the branching and to emphasize the distinctive exogenous method of branching of the main axis. Although the branches occupy a marginal position in the mature thallus, their method and place of initiation (from a segment cell of the apical cell) is fundamentally different from that of the marginal branches in various other Delesseriaceae. The marginal branches in these genera (e. g., members of the *Membranoptera* group) are initiated by cells which lie at the margin of the blade and which are not directly joined to an axial cell of the parent axis.

Although we are not yet fully informed on the development of the procarp, cystocarp, and spermatangia of *Taenioma*, the fact that *Taenioma* and *Caloglossa* are the only Delesseriaceae that show exogenous branching suggests that these two simple genera may be related. Certain other features of agreement (e. g., monopodial growth, alternate branching) also support this belief. I propose, therefore, to transfer *Taenioma* from the *Sarcomenia* group, where it has been an aberrant member, to the *Caloglossa* group.

The formation of a connecting cell by the carpogonium in *Caloglossa* (whereby a diploid nucleus presumably is delivered to the auxiliary cell when the connecting cell and the auxiliary cell fuse) is an interesting feature that has not heretofore been observed in any of the many genera of Delesseriaceae that have been studied. In the Ceramiales, the presence of a connecting cell is generally regarded as indicative of a primitive condition. Connecting cells are formed in the genera *Callithamnion*, *Spermothamnion* and *Ptilota* of the Ceramiaceae and in *Dasya* of the Dasyaceae. The occurrence of such a cell in a member (*Polysiphonia platycarpa*) of the remaining family of this order, the Rhodomelaceae, as reported by IYENGAR and BALAKRISHNAN (1949, 1950), has been justifiably questioned by SCAGEL (1953, p. 10).

The presence of a connecting cell in *Caloglossa* thus lends support to the view of KYLIN (1956, pp. 398, 427) that *Caloglossa* is one of the most primitive genera of Delesseriaceae. On other grounds, PAPENFUSS (1944, p. 207) has considered *Taenioma* as the simplest of known Delesseriaceae. These two genera clearly appear to be related, but it may be difficult to decide which of them is more primitive. It seems likely, however, that *Taenioma* is the more advanced of the two genera and that its simple structure is not a primary feature but the result of reduction. This is suggested by the fact that the typical delesseriaceous construction of the frond only appears in the determinate (potentially fertile) branches whereas the strictly vegetative branches are terete.

The systematic position of the remaining genera of the old subfamily Sarcomenieae (Sarcomenioideae) is a question which appropriately may be considered here.

KYLIN (1956) has referred *Zellera* and *Implicaria*, in addition to *Claudea* and *Vanvoorstia*, to the *Claudea* group, and he (October, 1956) and PAPENFUSS (September, 1956) have independently reduced the monotypic *Sonderia* to the synonymy of *Vanvoorstia*. The assigning of *Zellera* to the *Claudea* group is probably justified. The type and only species of *Implicaria*, however, has been shown by SEGAWA (1939, 1941) to be *Vanvoorstia coccinea*.

With the removal of *Taenioma* to the *Caloglossa* group, the *Sarcomenia* group of KYLIN thus comprises the genera *Sarcomenia*, *Platysiphonia*, *Cottoniella* and the three new genera that were recently established by WOMERSLEY and SHEPLEY (1959): *Sarcotrichia*, *Dotyella* and *Malaconema*. According to these authors (p. 220), *Sonderella* is not a member of the *Sarcomenia* group but belongs to the Rhodomelaceae.

In recent years an important fact has been brought to light about the ontogeny of the thallus in members of the *Sarcomenia* group, which seemingly casts doubt on the long-held view that these algae belong to the Delesseriaceae. SILVA and CLEARY (1954), in a detailed study of *Platysiphonia*, established that in this genus the pericentral cells are not produced as in other Delesseriaceae, namely, first the two lateral pericentral cells and then the two transverse ones, but in an alternating sequence as in Rhodomelaceae. They further observed that this is also true of *Cottoniella* and *Vanvoorstia*. In *Claudea* and *Caloglossa*, on the other hand, they found the pericentral cells to be formed in the usual delesseriaceous sequence.

DOTY and WAINWRIGHT (1958) observed that in a new species, which they referred to *Cottoniella* (but which has been made the type of the new genus *Dotyella* by WOMERSLEY and SHEPLEY), the pericentral cells were also formed in the rhodomelaceous sequence.

In a significant paper on the Australian members of the *Sarcomenia* group, WOMERSLEY and SHEPLEY (1959) not only confirmed the findings of SILVA and CLEARY and of DOTY and WAINWRIGHT with respect to the sequence of pericentral cell formation in *Platysiphonia*, *Cottoniella* and *Dotyella* but observed that the rhodomelaceous plan also is found in *Sarcomenia*, *Sarcotrichia* and *Malaconema*. The rhodomelaceous sequence of pericentral cell formation is thus shown by all the genera of the *Sarcomenia* group in the strict sense (i. e., excluding *Taenioma*) and by *Vanvoorstia* in the *Claudea* group.

Largely on the basis of the rhodomelaceous sequence of pericentral cell formation and the putative sympodial method of growth of the gonimoblast, WOMERSLEY and SHEPLEY contend that the *Sarcomenia* group should be removed to the Rhodomelaceae as a subfamily Sarcomenioideae.

I do not agree with the opinion of WOMERSLEY and SHEPLEY and will present my arguments for retention of the *Sarcomenia* group in the Delesseriaceae by way of a review of the main characters whereby the Delesseriaceae and Rhodomelaceae have been distinguished. Emphasis will be placed on the subfamily Delesserioideae because the members of the second subfamily of the Delesseriaceae, the Nitophylloideae, are strikingly different from both the Delesserioideae and the Rhodomelaceae and a consideration of them is not germane to this discussion.

(1) As has already been mentioned, in the Delesserioideae, with the exception of *Vanvoorstia* and members of the *Sarcomenia* group, the two lateral pericentral cells are formed first and then the two transverse pericentral cells, whereas in the Rhodomelaceae the pericentral cells are formed in an alternating sequence with reference to the first one, and the last-formed pericentral cell always lies diametrically opposite the first one. Although the delesseriaceous plan of pericentral cell formation holds for the great majority of Delesserioideae, this character can no longer be

used without qualification in the separation of this subfamily from the Rhodomelaceae. In consideration of the agreement in various structural and reproductive features among members of the *Claudea*, *Caloglossa* and *Sarcomenia* groups, it seems illogical to separate these genera into different families. Even by removing the *Sarcomenia* group to the Rhodomelaceae, the family Delesseriaceae would still remain "impure" through the retention in it of *Vanvoorstia*, which clearly should not be removed from this family.

(2) In the Delesserioideae the lateral pericentral cells function as initials which, through segmentation, produce lateral rows of cells (flanking cells); and two such rows issue directly from the pericentral cells. As regards the *Sarcomenia* group, this method of blade development is especially evident in *Sarcomenia*, the type of the group (see WOMERSLEY and SHEPLEY's fig. 1). However, even in those genera of the Delesserioideae in which the vegetative thallus is terete (i. e., lacks flanking cells), this condition shows up in the reproductive branches (*Malaconema* and *Dotyella* of the *Sarcomenia* group) or potential reproductive branches (*Taenioma*). The fact that typical delesseriaceous flanking cells are formed in the reproductive parts of these genera is of special interest because it probably signifies a reversion to the basic condition characteristic of the subfamily.

It is evident, therefore, that as far as known all Delesserioideae, at least at some stage in their development, exhibit this fundamental anatomical feature of flanking cell formation. With the exception of vegetative *Malaconema* and *Dotyella*, any genus of the Delesserioideae thus can be immediately recognized as a member of the subfamily from a glance at the tip of the thallus. (*Taenioma* at all stages possesses determinate – potentially fertile – branches and presents no problem.)

(3) All Delesserioideae, including members of the *Sarcomenia* group, lack trichoblasts, whereas the Rhodomelaceae (with only a very few exceptions) possess trichoblasts, at least at some stage in their development.

(4) In all Delesserioideae, including members of the *Sarcomenia* group, the female and male sex organs are produced directly on the main thallus or on determinate branches of the thallus, whereas in the vast majority of Rhodomelaceae the sex organs are formed on the trichoblasts. The localization of the sex organs on the trichoblasts is one of the most characteristic features of the Rhodomelaceae. Even the few genera of Rhodomelaceae that at no stage in their development produce trichoblasts

are not a source of systematic uncertainty because they reveal their rhodomelacean alliance by other features characteristic of this family.

(5) A sharp distinction between the Delesserioideae and Rhodomelaceae lies in the number of pericentral cells formed in procarp-producing segments. Irrespective of the number of pericentral cells present in vegetative parts, procarp-bearing segments in Rhodomelaceae, with the exception of *Laurencia*, always form five pericentral cells. (Four pericentral cells are formed in procarp-bearing segments of *Laurencia*.) In members of the *Sarcomenia* group, as in all other Delesserioideae, the procarp-bearing segments contain only four pericentral cells.

(6) KYLIN (1956, pp. 347, 398) has used the method of development of the gonimoblast as a key character for separating the Delesseriaceae from the Rhodomelaceae: the gonimoblasts supposedly show monopodial growth in the Delesseriaceae, whereas they show sympodial growth in the Rhodomelaceae.

According to SILVA and CLEARY (1954), the gonimoblast of *Platysiphonia* exhibits sympodial development and WOMERSLEY and SHEPLEY believe this to be true also of the gonimoblasts of all the members of the *Sarcomenia* group of which they had cystocarpic material. WOMERSLEY and SHEPLEY (1959, p. 214) believe, moreover, that if Kylin had known this he "... would doubtless have placed it [the *Sarcomenia* group] in the Rhodomelaceae ...". In view of the several clear-cut delesseriaceous characters possessed by members of the *Sarcomenia* group and of KYLIN's intimate knowledge of the Delesseriaceae, I seriously doubt that he would have done this.

In evaluating this character two separate and yet related questions come up for consideration. First, what is the evidence that the development of the gonimoblast is monopodial in the Delesseriaceae and sympodial in the Rhodomelaceae? Second, how firmly is it established that the gonimoblast of members of the *Sarcomenia* group shows sympodial growth?

It is clear that WOMERSLEY and SHEPLEY are not entirely convinced of the significance of this character and I share their doubts as to its value as a distinguishing feature. In view of KYLIN's profound knowledge of these two families, it is not unlikely that he was correct, but his published figures do not provide evidence in support of his belief.

Even in vegetative material of the algae, it is frequently difficult to be sure whether an axis shows monopodial or sympodial growth. And in a compact structure such as the gonimoblast, it becomes even more difficult to determine the method of growth. (Dr. FAN and I were unable to establish the method of growth of the gonimoblast of *Caloglossa.*) Furthermore, the method of development would have to be determined from study of a young gonimoblast because the formation of a carposporangium by the terminal cell of a gonimoblast filament terminates (at least until the carpospore has been released) the growth by segmentation of that apex, and a branch, if formed, is then usually produced by the cell below the carposporangium. This would cause such a filament to show sympodial growth, whereas in the younger condition the development may have been monopodial.

Turning to the second question raised above, none of the figures of gonimoblasts given by WOMERSLEY and SHEPLEY of members of the *Sarcomenia* group convincingly prove that the branching is sympodial and the same is true of SILVA and CLEARY's figure 36, which, according to them, illustrates sympodial branching. In fact, I would interpret SILVA and CLEARY's figure as showing a monopodial main axis (toward the left) that has produced three lateral branches whose apical cells are in an early stage of transformation into carposporangia and the subterminal cells of which are in the process of forming branches.

It would seem, therefore, that for the present the method of growth of the gonimoblast should be accepted with reservation as a criterion for the separation of the Delesseriaceae and Rhodomelaceae. Also, on the basis of present meager knowledge of the pattern of growth of the gonimoblast in members of the *Sarcomenia* group, it seems premature to conclude that growth in them is sympodial and hence in accordance with the plan allegedly characteristic of the Rhodomelaceae.

(7) One of the most clear-cut differences between the Delesserioideae and Rhodomelaceae, as far as known, lies in the time of formation of the cover cells of the tetrasporangia. In the Delesserioideae, including the members of the *Sarcomenia* group, the cover cells are always formed after the sporangium has been initiated, whereas in the Rhodomelaceae they are formed before the sporangium is initiated. WOMERSLEY and SHEPLEY state (p. 217): "It is possible, however, that the flanking cells of the *Sarcomenia* group stichidium should be interpreted as cover cells comparable to those of the Rhodomelaceae . . .", that is, cover cells that are formed before the sporangia are initiated. These authors, however, confirmed the fact that the real cover cells are formed, as in other Delesserioideae, after the sporangium has been initiated. In members of the *Sarcomenia* group, some protection is provided for the tetrasporangia by the transverse pericentral cells and the flanking cells, in addition to that

furnished by the cover cells (see SILVA and CLEARY's figs. 27 a and 27 b). However, the flanking cells are not homologous to the cover cells of Rhodomelaceae. They are typical delesseriaceous flanking cells and are homologous to those in vegetative and sexual plants as will be seen from a comparison of WOMERSLEY and SHEPLEY's figures 1, 6, 10 and 13 of *Sarcomenia delesserioides* and of SILVA and CLEARY's figures 6, 16, and 24 of *Platysiphonia parva*.

In my opinion, it thus would be incorrect to place the members of the *Sarcomenia* group anywhere else than in the Delesseriaceae, where they occupy a place within the subfamily Delesserioideae, seemingly not far removed from the *Claudea* and *Caloglossa* groups.

Acknowledgments

This study was carried out with the aid of a grant from the National Science Foundation. The material was collected with the assistance of a grant from the Carnegie Corporation of New York through the University of Cape Town. Grateful acknowledgment is made for this aid. I should like to thank Dr. KUNG-CHU FAN for assistance with the research and Mrs. EMILY REED for assistance with the drawings. Dr. MAX HOMMERSAND kindly read the discussion and constructively criticized it.

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Manuscript received September 19, 1960.

Pseudobryopsis oahuensis in Hawaii[1]

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While in the Hawaiian Islands during 1959 I made several collections of *Pseudobryopsis* and had opportunity to study additional material collected by others. Preliminary examination of these collections suggested that three or four entities were to be recognized. Careful study has led me to conclude, however, that all of the material represents *Pseudobryopsis oahuensis* EGEROD (1952, p. 372) and that this species is much more variable than would be anticipated from the original description.

In her excellent account, EGEROD reported *Pseudobryopsis oahuensis* as having among other characteristics (1) plants 3–5 cm. tall, composed of a simple or rarely bifurcate axis, 400–500 μ wide, (2) the pinnae filiform, about 30 μ wide and 2.5 mm long, simple or rarely divided, and (3) up to five ovate gametangia borne on the lower half of the pinnae along the adaxial surface. Some of the variations in terms of these three areas are discussed below.

The material collected by Dr. A. J. BERNATOWICZ on February 26, 1959, from a concrete pier at the Diamond Head end of Kuhio Beach, Waikiki, represents in almost all particulars the type description (Figs. 1, A and 2, A). The same is true of PAPENFUSS 10618, cited by EGEROD as an additional collection of *P. oahuensis*, material of which was kindly provided for my study by Dr. G. F. PAPENFUSS.

Some marked deviations from these plants are found in material of *Pseudobryopsis oahuensis* which was growing attached to coral 3–6 feet below the surface in rather swift current at Moloaa, Oahu. In these plants the pinnae are consistently smaller in diameter and many are once or twice, and rarely, three times dichotomously branched. For example, the

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[1] This study was supported by a grant from the National Science Foundation (Grant No. G-7107).

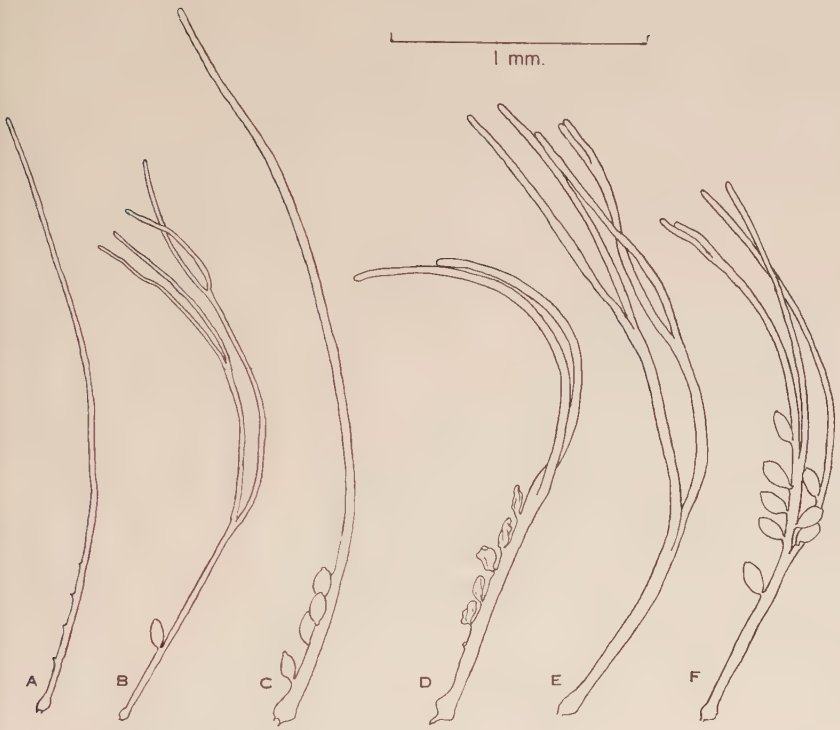

Fig. 1. Camera lucida sketches of pinnae of *Pseudobryopsis oahuensis* EGEROD. A, simple pinna from BERNATOWICZ, Feb. 26, 1959, collection, showing scars of gametangia on adaxial surface near base; B, branched pinna with very narrow ultimate branchlets from GILBERT 9344; C–F, variations in pinna from GILBERT 9701.

pinnae in plants of GILBERT 9344, April 2, 1959, are as a rule once or twice dichotomously branched (Fig. 1, B) and range in diameter from 24–33 μ near their bases to only 13–17.8 μ in the ultimate branchlets. Probably as a result of the narrow diameter, these pinnae, both in living and preserved material, do not appear to curve as markedly toward the apex of the plant as do the wider pinnae of the type material and as do all of the pinnae in my collections that reach 30 μ or more in width. The gametangia in this material range somewhat smaller than in EGEROD's description, but in every instance some fall within the size range she indicated. In addition, in many collections studied, with the exception of the material in GILBERT 9345 and 9486, noted below, some of the gametangia are obovate (Fig. 2, B) rather than ovate. In a few instances the obovate shape is predominant.

Another interesting variation of the gametangia appeared in two clumps of *Pseudobryopsis* also collected at Moloaa (GILBERT 9354, April 4, 1959 and 9486, April 16, 1959). In this material the pinnae are all simple, 21–25 μ diameter, extremely close-packed, but the most unusual aspect is the shape of the gametangia which are crowded together near the bases of the pinnae. These gametangia are asymmetrical (Fig. 2, C–E) and average about 58 μ in width by 91 μ in length. No mention is made in the literature of asymmetrical gametangia for any species of *Pseudobryopsis.* The temptation is great to name these two collections as a variety, but since both clumps were sorted out from among many clumps having symmetrical gametangia it seems best to simply note this variation and wait until the taxonomic picture becomes clearer through additional collections and through cultural and life history studies.

In a large collection from the island of Kauai (GILBERT 9701, from clay tile, Kauai Boat Club, between Kekaha and Waimea, April 30, 1959) there are plants which nearly duplicate the type description but also larger specimens which are so different that they might well be described as a new species if one were unaware of the many intermediates to be found in the same collection. Among the plants in this collection are some which have pinnae that are nearly all simple and approximately 30–40 μ in diameter (Fig. 1, C) while others are more robust, having pinnae that are commonly twice- and three-times (rarely four) dichotomously branched and which range in size from 50–68 μ in diameter below the first dichotomy to 25–36 μ in diameter in the ultimate branchlets (Fig. 1, D–F). Of considerable interest, as well, is that some of these large pinnae bear as many as 19 gametangia spread out over some distance along the length of the pinnae. Where there are but four or five gametangia per pinna they are always found on the adaxial surface near the base of the pinna. When larger numbers are produced some are found farther out on the pinna between the first and second dichotomies and, rarely, beyond the second dichotomy (Fig. 1, F). In most instances the adaxial position is maintained even beyond the first dichotomy, but this is not always true. Even in those plants which produce large dichotomously branched pinnae bearing many gametangia it is possible to find some simple pinnae that are similar in form and approach the size of the pinnae in the type description.

The water where the Kauai material was collected was exceedingly muddy during the incoming tide and was relatively quiet, being protected by a breakwater. Mud was trapped between and toward the bases of the

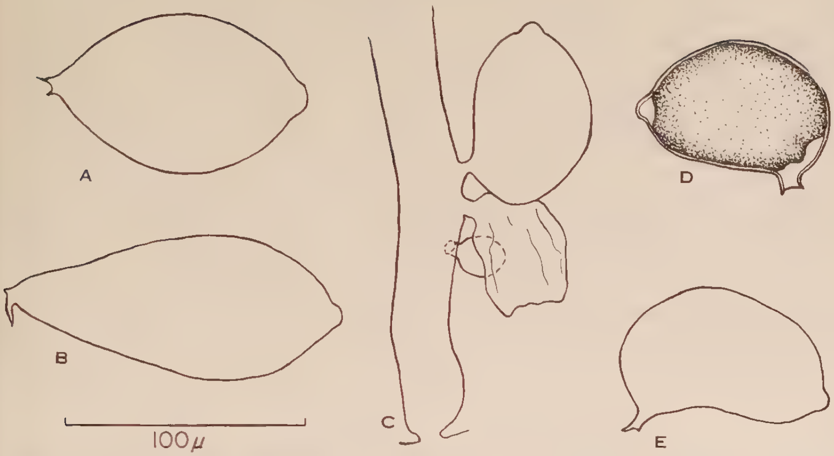

Fig. 2. Camera lucida sketches of gametangia of *Pseudobryopsis oahuensis* EGEROD. A, ovate gametangium from BERNATOWICZ, Feb. 26, 1959, collection; B, obovate gametangium from GILBERT 9701; C, base of pinna showing crowded asymmetrical gametangia in GILBERT 9354; D and E, additional sketches of asymmetrical gametangia.

pinnae. It seems quite possible that the rank habit of many of these plants is related to the ecological situation.

As described by EGEROD, the type material is 3–5 cm tall with the central axis simple or rarely bifurcate and 400–500 µ wide. Many of the plants in the collections I have studied are branched and taller, commonly to 7.5–9.0 cm in GILBERT 9701, and in a single plant collected by ROBERT REISNER in the spring of 1958 from deep water off Kailua Beach, Oahu, the axis is repeatedly branched and reaches 16 cm in length. In these larger plants the diameter of the main axis reaches 800 µ and some of the pinnae attain a length of 2.9 mm.

In comparing *Pseudobryopsis oahuensis* with other known species, EGEROD (1952, p. 373) suggested that the Hawaiian plants she studied were not very widely divergent from the plants reported by BØRGESEN (1925) and FELDMANN (1937) under the name of *P. myura* (J. AG.) BERTHOLD. As a point of difference EGEROD called attention to the height (15 cm) of the specimens from Banyuls reported by FELDMANN in contrast to the shorter plants (3–5 cm) from Oahu. While it now appears that occasionally *P. oahuensis* can attain a height of as much as 16 cm it still appears to be distinct from *P. myura* on the basis of the commonly branching pinnae and the abundance of gametangia.

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Manuscript received October 24, 1960.

PHYCOLOGIA 1 (1) 1961

Observations on the Fine Structure of *Paraphysomonas vestita,* with special reference to the Golgi Apparatus and the Origin of Scales.

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(With 24 Figures on Plates I–VII)

Introduction

The observations recorded here were obtained, in a sense, accidentally. The organism in question, *Paraphysomonas vestita* (STOKES) DE SAEDELEER, was encountered as a contaminant in a recently established culture of a small pigmented flagellate from Lake Windermere which was under investigation. The presence of the contaminant was at first disregarded since it is so different in size and appearance from the other organism that confusion between them was impossible. When the main investigation had been completed a few micrographs of the *Paraphysomonas* were taken and only then did its special suitability for the study of several problems of current interest become apparent. All available preparations were thereupon searched for further information regarding the contaminant and the remaining embedded material was sectioned. By this time several months had elapsed since the original fixations had been made and during this interval the *Paraphysomonas*, having acted as a predator on the pigmented flagellate, had destroyed the culture and itself died out. The work cannot therefore be extended without a fresh isolation of the organism, but fortunately a preliminary study of the living cells had been carried out before the culture was lost.

The methods used have been those now standard for work of this kind. The techniques of light microscopy, using anoptral contrast, are as described in MANTON & LEEDALE (1961 a). Those required for electron microscopy of whole mounts and sections are too well-known to need detailed description; essentially they involve fixation with osmium tetroxide (vapour for whole mounts, 2% solution buffered to pH 7 for sections), embedding in n-butyl methacrylate, sectioning on a Porter-Blum Sorval microtome with a glass knife and examining the sections (mounted on carbon films) with a Siemens Elmiskop I.

Grateful thanks are due to Dr. J. LUND of the Freshwater Biological Association's station at Lake Windermere and Dr. M. PARKE of the Plymouth laboratory of the Marine Biological Association for supplying us with material, to Mr. K. OATES for making the shadow-cast preparation used for Fig. 13 and to Miss SHEILA M. WRIGHT for help in preparing the plates for publication.

Nomenclature and Early History

Paraphysomonas vestita (STOKES) DE SAEDELEER is a strongly heterokont colourless flagellate of the *Ochromonas* type and thus a member of the Chrysophyceae. Both stalked and free-swimming states are known although we have studied only the latter. The species was first described in 1885 by STOKES under the name of *Physomonas vestita*, from material consisting only of cells in the stalked condition. The cell size which he quotes as 11 µ is slightly less than that in our material (12–20 µ) though this difference is not beyond the range which might reasonably be expected to occur in specimens from different localities. STOKES' description (1885, 1888) is good as far as it goes, though he could not interpret the investment of spined scales (see below) which he regarded as "permanent, non-vibratile, hair-like prolongations" of the "cuticular surface" of the cell. He was also unable to see the nucleus and presumed that it must lie centrally in the cell, whereas we now know that it is held close to the cell surface by the flagellar bases to which it is attached.

The species was studied subsequently by at least two light microscopists, namely KORSCHIKOV (1929) and REYNOLDS (1934). The latter we may disregard since he was apparently unaware of the very much better earlier work of KORSCHIKOV, and his description contains numerous misconceptions. KORSCHIKOV (1929), however, is excellent. He studied both states of the species and we have included one of his drawings (Fig. 14) in illustration of the external scales. Had space permitted we could also profitably have included his drawings of the complete cell.

Finally, the change of generic name from *Physomonas* to *Paraphysomonas* has been made necessary to conform to the International Rules of Nomenclature by the fact that the only other species of *Physomonas*, originally described as *P. socialis* by KENT in 1880, has more recently been re-interpreted as a species of *Monas*. The removal of the type species to another genus invalidates the name *Physomonas*, and the new name, *Paraphysomonas*, was proposed as a substitute by DE SAEDELEER in 1929. *P. vestita* (STOKES) DE SAEDELEER is still the sole known species of this genus.

Mode of Occurrence and External Morphology

The species, under one or other of its two names, has been recorded from standing freshwater (ponds, lakes, reservoirs etc.) from several parts of the northern hemisphere. It is probably more common than the light microscopy suggests since the scales, by their very striking appearance at higher magnifications, have already attracted the attention of at least two electron microscopists (HOUWINK, 1952, TAKAHASHI, 1959, 1960) working with natural samples from localities in which the species had not previously been recorded. Being entirely phagotrophic in nutrition, the local populations must wax and wane with the incidence of suitable food supplies. KORSCHIKOV (1929) explicitly states that an excellent food for his material was a species of purple sulphur bacterium (*Chromatium okenii*) and we have encountered an association of *Paraphysomonas* with *Chromatium* in a pond near Leeds. In our mixed culture, the *Paraphysomonas* was living on a species of *Chrysochromulina* (Chrysophyceae) but it also ingested other smaller micro-organisms (e.g. the numerous bright spherical objects in living cells in Figs. 1–7), some of which it seemed unable to assimilate. No detailed studies of food relations have been made but the egestion of an apparently undigested object is recorded incidentally in Plate I (arrows in Figs. 1 and 2).

The characteristic ovoid or pyriform shape of the swimming cells is retained by the living, though rather flattened, specimens illustrated in Figs. 1, 6 and 7. The two very unequal flagella, respectively 40–45 μ and 6 μ in length, are discernible in Fig. 4. No other observations have been made by us on flagellar morphology but incomplete evidence was produced by KORSCHIKOV (1929) for the presence of hairs (Flimmer) on the long, front, flagellum and this has been fully confirmed on electron micrographs of shadow-cast material by HOUWINK (1952). The range of cell sizes in our material agrees with that given by KORSCHIKOV (12–20 μ) though our figures are based on rather few measurements and we cannot exclude the possible presence in our cultures of some smaller cells comparable with those (11 μ) measured by STOKES (1885).

The surface covering of detachable scales is clearly visible in life (Plate I); their number is of the order of 100 per cell. KORSCHIKOV's very accurate drawings of individual scales seen by ordinary transmitted light (Fig. 14) can usefully be compared with the same object as seen by anoptral contrast microscopy (Plate I) and with the low power of the electron microscope (Fig. 13). Each scale consists of a circular flat disc approximately 2 μ in diameter (range 1–2.5 μ) from the centre of which rises a slender tapering spine up to 10 μ in length (range 2–10 μ). The approximate measurements are taken from living cells and agree with those of KORSCHIKOV (1929). The more precise size range is measured from Fig. 13, selected to display the diversity of size which can be found and which requires the resolving power of the electron microscope for numerical assessment. When cut in section, both spine and disc are seen to be hollow and two-layered, the two layers of the spine being in continuity with the two layers of the disc; the cavity up the centre of the spine is thus open to the exterior. Mineralization of the scales is obvious in electron micrographs; investigations by KORSCHIKOV (1929) of their chemical nature led him to the conclusion that the mineral is silica.

Cell Contents

The components recognisable within a living cell include the nucleus, a Golgi body (previously called "mouthband", see below), a contractile vacuole, ingested particles, small fat bodies, other droplets and vesicles of various sizes and, in favourable cases, a patch of apparently homogenous material which, guided by KORSCHIKOV (1929), we interpret as leucosin; the latter is labelled "L" in Figs. 6 and 7, while good views of most of the others will be found labelled in Figs. 2, 3, 6 and 7.

When seen in section with the electron microscope the cells seem much emptier than those of related pigmented flagellates which commonly appear densely crowded with contents. This impression could be partly illusory, resulting from imperfect fixation of some cytoplasmic component, but its principal basis is likely to be a genuine expression of the absence of plastids and the presence throughout the cytoplasm of large numbers of vesicles and vacuoles of various sizes. The larger vacuoles may appear full or empty. Their nature can sometimes be diagnosed in terms of contents, e.g. food vacuoles (see especially Fig. 21), or in terms of the evidence provided by the light microscope, e.g. the contractile vacuole (see especially Figs. 12 and 20). Apart from these, the larger organelles recognisable in electron micrographs of sections include the nucleus, the Golgi body and numerous mitochondria, the latter identified not in terms of light microscopy, with which they are invisible in untreated living cells, but because of the characteristic fine structure well known from other organisms.

The new observations that we wish to record regarding these various cell components fall into four main topics: (a) the spatial relationship between the flagellar bases and the nucleus, (b) preliminary observations on the contractile vacuole, (c) the Golgi body and (d) observations on the origin of scales.

Flagellar bases and the nucleus

As KORSCHIKOV (1929) correctly states, the nucleus "is ovoid or pyriform in shape, the narrowed end being approached close to the point of insertion of the flagella". In living cells it is easy, with anoptral contrast, to demonstrate the nucleolus and nuclear membrane (Figs. 2–5, 7), with the basal bodies of the two flagella also visible in favourable cases (Fig. 7). Owing to the large size of the cell it is not always possible to obtain transects through exactly the right region, but micrographs from four different specimens cut in various planes are included in Plate II from which salient features in the relation of nucleus to flagellar bases and of the structures involved can be determined.

The nuclei themselves are of normal construction with a very conspicuous perinuclear space visible in all planes of section (Figs. 8, 12, 19 b) and with one or sometimes two (Fig. 9 b) nucleoli. Whether the hollow centre of the nucleolus in Fig. 8 is characteristic of a particular stage or only of a certain plane of section is unknown. Immediately behind or beside the point of contact with the flagellar bases, the nucleus is commonly pulled out into a beak-like process. This can be seen best in Fig. 10 b, though interpretation of this section requires comparison with the same cell cut at a different level in Fig. 10 a and with the two sections cut in a plane at right angles to this in Figs. 9 a and 9 b.

The tip of the nucleus is held to the cell surface by means of a fairly massive bundle (or bundles) of cross-banded fibres, some of which are well seen in Figs. 10 a and 10 b. Similar fibres pass down the sides of the nucleus (Figs. 8, 9a and 11) and are doubtless responsible for holding the flagellar bases against the nuclear surface. How many bundles of fibres are involved in these two processes is uncertain, but a probable number is four; three are separately visible in the series represented by Figs. 9 a and 9 b. Exactly how contact is maintained between these fibres and either the flagellar bases or nuclear surface is unknown though it cannot be doubted that the method is mechanically effective.

The contractile vacuole

The contractile vacuole in living cells occupies a characteristic position beside the nucleus and near to the Golgi body (Figs. 2–6). Both STOKES (1885) and KORSCHIKOV (1929) describe two contractile vacuoles which pulsate alternately but we have not seen this except in dividing cells. The single vacuole forms by the confluence and emptying into it of several accessory vacuoles (Fig. 6). Vacuolar discharge (Fig. 1) occurs at intervals of approximately one minute.

The relatively constant position of this organelle enables it to be identified with certainty in EM sections. It is shown at two magnifications in Figs. 12 and 20 respectively. The lumen of the main vacuole or vacuoles is delimited by a somewhat convoluted bounding membrane outside which there are many smaller vacuoles which could not be seen with the light microscope, and which are almost certainly emptying into it (Fig. 20). The opening to the outside is presumed to be temporary since we have not encountered it as a definite duct, though this might merely mean that none of our sections has passed through it.

The Golgi body

In living cells under anoptral contrast, the Golgi body is clearly visible as a bright rod beside the nucleus and near to the contractile vacuole (see especially Figs. 3 and 6). In electron micrographs of sections, it is detectable as a dense streak in a low power view (Fig. 12) or as an array of irregular vesicles when cut obliquely (Fig. 20). In median section at high powers (Fig. 22), we find the characteristic stack of paired membranes or flattened cisternae by which Golgi bodies can be generally recognised.

It is obvious from its position that this stack of Golgi cisternae is the so-called "mouthband" (= "Mundleiste", "bandelette buccale") of previous authors (and the "stigma" described by REYNOLDS, 1934). STOKES (1885, 1888) described a "linear, slightly curved band or groove near the frontal margin of the body"; KORSCHIKOV (1929) described a "strongly refracting plate" of "quite obscure" nature and function, the ends of which merged into the surrounding cytoplasm which appeared vacuolated in osmic-fixed cells. This position near the flagellar bases is not at all uncommon in pigmented flagellates (e.g. the several species of *Chrysochromulina* recently described by PARKE, MANTON & CLARKE, 1958, 1959, MANTON & LEEDALE 1961 a, 1961 b), but we have never previously encountered a cell in which the single Golgi body is as large as in *Paraphysomonas vestita.*

Compared with the abundance of sections traversing the Golgi body more or less perpendicularly those showing it in face view are both scarcer and less clear. The scarcity is an obvious consequence of the differences of dimensions in the various planes but the lack of clarity is caused by curvature of the cisternae which are flat and parallel only in the centre of the organelle, diverging peripherally (Fig. 22); a polar section can therefore never accurately expose the face view of an entire cisterna. An approximation to a polar view is nevertheless included in Fig. 23, at a slightly lower magnification than that of Fig. 22. The superposed cisternae appear to be fenestrated near their edges (as in most other known cases) but in addition there are marked signs of abstriction of numerous small dense-walled vesicles. This can be traced to some extent also in Fig. 22 but to increase the evidence part of a polar view of the Golgi body from another specimen is reproduced in Fig. 24. The nature and fate of these abstricted vesicles is entirely unknown but they are highly characteristic objects in the immediate neighbourhood of the Golgi body in these cells.

Origin of the scales

The morphology and structure of the scales have already been described (p. 40 above), salient features being their large size, highly distinctive shape and mineralized condition. This last attribute makes even small pieces cut in thin sections opaque to the electron beam and an immediate consequence is the ease and frequency with which scales can be detected inside cells. Immature scales cannot yet be recognised but it is scarcely possible to section any cell without encountering some, or many, apparently mature ones inside it. The numbers and distribution vary somewhat from cell to cell and also possibly in different parts of the same cell, a detail that cannot as yet be explored electron microscopically owing to the relatively short runs of serial sections normally available. When favourably placed, notably when cut longitudinally through the spine and subtending disc, even a single scale can become so conspicuous as to arrest attention (Figs. 15, 19 a), and once this has been discovered the presence of many other less conspicuous profiles can readily be demonstrated.

A large scale such as that illustrated in Fig. 15 can often be shown to traverse almost the entire width of the cell although it is usually necessary to trace it through several sections to prove this. An example of a scale of this kind has been reconstructed (Figs. 19 a, 19 b) by putting together opposite sides of the cell from two different sections of a series. Fig. 19 a shows the disc near to the nucleus and cell surface. Fig. 19 b shows the distal end of the spine about to penetrate the cell surface at the opposite side. The spine tip is still covered by the cell membrane which is distorted though not yet punctured.

Single scales cut in oblique transverse section are very numerous. When the disc is represented we see the large circular profile with central disturbance marking the attachment of the spine, as in Figs. 16 or 21. Profiles through the spine are small and densely opaque; three are indicated by the short arrows in Fig. 19 b.

Internal scales are by no means always encountered singly. Fig. 17 shows a section with three apparent vacuoles (or parts of vacuoles), each conspicuously crowded with a large number of scales. While the total shape of such scale-filled vacuoles cannot be directly determined they are certainly not simple spheres. Fig. 18 is from an adjacent section through the specimen of Fig. 17 and represents part of the uppermost vacuole at a higher manification. The contour is deeply lobed, especially on the left hand side, where two long evaginations (arrows) containing scales, project into the cytoplasm.

Scale-filled vacuoles such as those of Figs. 17 and 18 do not at all resemble food vacuoles although it should not be forgotten that this species is phagotrophic and some scales could conceivably become ingested during feeding. The numbers actually found are however so large that it seems unlikely that so many could have become accidentally ingested and it is equally possible that none need have entered in this way since very recent food vacuoles, containing clearly recognisable objects such as a newly ingested cell of a *Chrysochromulina*, are commonly completely devoid of scales. On the other hand the suggestion that the internal scales found are part of a developmental sequence is consistent with the structural observations. In particular, the lobing of vacuoles as in Fig. 18 and the suggestion of imminent fusion between the cell body membrane and a residual vacuolar membrane surrounding a spine about to penetrate the cell surface (Fig. 19 b, bottom left), could conceivably be interpreted as stages in the transfer of individual scales to the outside, although this process cannot yet be directly observed.

It had been hoped that scale development might have been traceable in living cells by means of anoptral contrast but the optical properties of the cytoplasm are such as to mask almost completely the presence of internal scales. Solitary scales can nevertheless sometimes be seen if favourably placed and we have reproduced part of Fig. 2 at a higher magnification in Fig. 5 in the hope of making more clearly visible the scale-base present in side view close to the nucleus, in a position very similar to that seen in Fig. 19 a. Its appearance in Fig. 2 should be compared with the identical appearance of scale-bases seen outside the cell in the same figure.

Discussion

The discussion can usefully be limited to comments on the main observations. Of these, the attachment of the flagellar bases to the nucleus, though interesting, is probably of least fundamental importance. A relation of this general type is usual among zoospores and motile gametes, with variations of detail as to the mechanism involved. In more permanently motile cells, on the contrary, many other conditions have already been encountered among a relatively small number of analysed cases. Thus in *Chlamydomonas* (SAGER & PALADE, 1957), *Pedinomonas* (MANTON & PARKE, 1960) and *Chrysochromulina* (PARKE, MANTON & CLARKE, 1958, 1959, MANTON & LEEDALE, 1961 a), connections between the flagellar bases and the cell surface or plastids are certainly more important mechanically than any direct association with the nucleus. At first sight this might suggest that the position in *Paraphysomonas* has been influenced by the absence of plastids. This is however not the case since an exactly similar condition is readily demonstrable (LEEDALE, unpublished) in closely related pigmented flagellates, notably species of *Ochromonas*. Some phyletic significance can therefore be attributed to this character though this also should not be overstressed since a general resemblance can be found in quite unrelated types (e. g. the male gamete of the green alga *Prasiola*, FRIEDMANN & MANTON, 1960).

The observations on the Golgi body, and in particular the close correlation between light and electron microscopy made possible by the exceptionally large size of this organelle, have removed a major source of confusion from algology. It is probable that many other flagellates for which a "mouthband" has been described will prove resolvable in similar terms, although it should be remembered that mitochondria also sometimes congregate near flagellar bases and can collectively resemble "a granule" when seen with the light microscope. If in doubt, vital staining will sometimes distinguish between these organelles but confirmation by electron micrographs is desirable. In spite of this element of uncertainty, discontinuance of the use of the words "mouthband", "Mundleiste" and "bandelette buccale" is strongly recommended since these terms embody so many fundamental misconceptions as to be actively misleading.

Finally, an origin of scales from vesicles within a cell and not directly from the body membrane has already been encountered in one other case (the green flagellate *Micromonas*, MANTON & PARKE, 1960), from which the complication of phagotrophic feeding is absent. It has been looked for in other scale-bearing members of the Chrysophyceae, notably species of *Chrysochromulina* for which complex scale patterns provide important taxonomic criteria, but the absence of mineralization and consequent poor visibility of such scales in sections has so far prevented their origin from being effectively traced (for a recent partial exception see MANTON & LEEDALE, 1961 b). The importance of *Paraphysomonas* lies in the clarity with which scales can be recognised with certainty in a great variety of positions; it is probably not otherwise exceptional. We may thus interpret it as offering an unusually clear view of a phenomenon which is probably widespread and therefore fundamental among scale-bearing micro-organisms in general.

Summary

The fine structure of *Paraphysomonas vestita* (STOKES) DE SAEDELEER has been studied by means of anoptral contrast microscopy of living cells and by electron microscopy of thin sections. The more important observations include demonstration of the attachment of the flagellar bases to the nucleus and cell surface by means of several systems of cross-banded fibres. The organelle previously referred to by light microscopists as the "mouthband", "Mundleiste" or "bandelette buccale" is shown to be a Golgi body of unusually large size but of normal construction; discontinuance of the supposedly descriptive, but very misleading, terms previously used is strongly recommended. Observations on the spined scales both outside and inside the body have given important insight into their probable mode of origin from internal vesicles and not from the external body membrane. A few preliminary observations on other cell components, notably the contractile vacuole, are also included.

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Manuscript received February 18, 1961.

Explanation of Plates I–VII

Paraphysomonas vestita (STOKES) DE SAEDELEER

Plate I

Figs. 1–4. Successive photographs with anoptral contrast of a living cell being gently flattened by pressure (time interval between Figs. 1 & 2, ten seconds; between Figs. 2 & 4, approximately 15 minutes), showing external scales, two unequal flagella (see especially Fig. 4), the nucleus (N), Golgi body (g), contractile vacuole (c.v.), small fat bodies (f) near the nucleus (especially Figs. 2 & 4), food vacuoles with bright spherical contents; one food particle being egested between the exposures for Figs. 1 & 2 (arrowed in these Figs.). × 1,500.

Fig. 5. More highly magnified nuclear region of Fig. 2 to show the head of an internal scale (arrow). × 2,000.

Fig. 6. Another living cell under anoptral contrast, viewed at right angles to that in Figs. 1–4, to show the Golgi body (g), leucosin vesicle (L) and the contractile vacuole with some smaller accessory vacuoles. × 1,500.

Plate II

Fig. 7. A somewhat flattened living cell under anoptral contrast, showing the flagellar basal bodies attached to the nucleus (N), and the single large leucosin vesicle (L). × 1,500.

Fig. 8. Section through a nucleus (N) and one flagellar base, with traces of the second base visible to the right and parts of fibrils running down the nuclear surface on the left (lower arrow); a trace of an upwardly directed fibril bundle also present (upper arrow). Micrograph B115, × 10,000.

Figs. 9a & 9b. Two sections (not immediately adjacent) from a series through a flagellar region showing the nucleus (N), parts of three systems of fibrils (arrows) and one flagellum (fb) cut in approximately transverse section. Micrographs H8027 & H8031, × 18,000.

Figs. 10a & 10b. Two successive sections through the tip of a nucleus (N) showing one basal body (fb) and two views of a system of fibrils joining the nucleus to the cell surface (arrows). Micrographs B103 & B107, × 20,000.

Fig. 11. Tip of a nucleus (N) from another specimen showing one flagellum in oblique TS and a very large group of striated fibrils (arrow). Micrograph H8002, × 20,000.

Plate III

Fig. 12. Complete transverse section of a cell showing external scales, the nucleus (N), contractile vacuole (cv), Golgi body, mitochondria, numerous vesicles and other small inclusions. Micrograph B88, × 8,000.

Fig. 13. A field of detached scales from a shadow-cast whole mount. Micrograph H8116, × 5,000.

Fig. 14. KORSCHIKOV's original drawing of scales (× 2,000) as seen with the light microscope (KORSCHIKOV, 1929).

Plate IV

Fig. 15. Section through a cell showing the head and part of the spine of a large internal scale cut longitudinally. Micrograph B1072, × 8,000.

Fig. 16. Part of a section of a cell showing the head of a scale (s) in face view within the cytoplasm, four mitochondrial profiles (m) above. Micrograph B1076, × 12,000.

Fig. 17. Section of a somewhat flattened cell showing three vacuoles (or three parts of one multilobed vacuole) filled with scales. Micrograph B94, × 8,000.

Fig. 18. Another section through the cell of Fig. 17 showing the uppermost vacuole at a higher magnification, for further explanation see text. Micrograph B100, × 12,000.

Plate V

Figs. 19a & 19b. Parts of two different sections of one cell combined to make a composite picture. Fig. 19a shows the head of an internal scale and the proximal part of the spine (long arrow), near the nucleus (N); Fig. 19b shows the distal end of the same spine (long arrow) at the opposite side of the body. Other spines (short arrows) in oblique TS elsewhere in the cytoplasm; vesicles with and without contents, several mitochondria, fat bodies etc. also visible. Micrographs H7979 & 7955, × 15,000.

Plate VI

Fig. 20. Part of a section of a cell showing the contractile vacuole (cv) surrounded by numerous small accessory vacuoles, Golgi body (g), nucleus (N) and a mitochondrion (m). Micrograph B533, × 20,000.

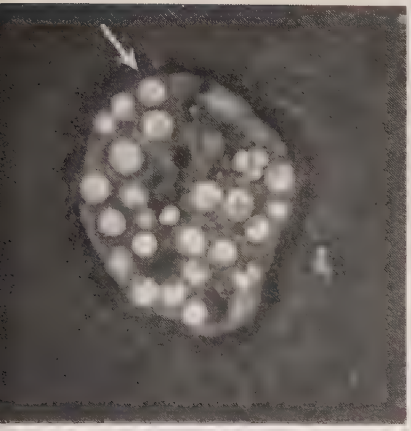
Fig. 21. Part of a section showing a food vacuole probably containing remains of a *Chrysochromulina* cell; a scale head (s) and two mitochondria (m) also visible. Micrograph B221, × 15,000.

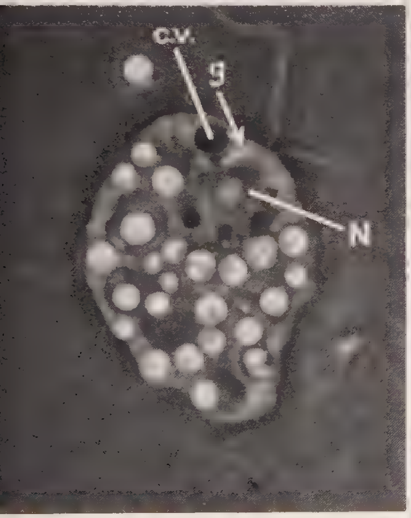
Plate VII

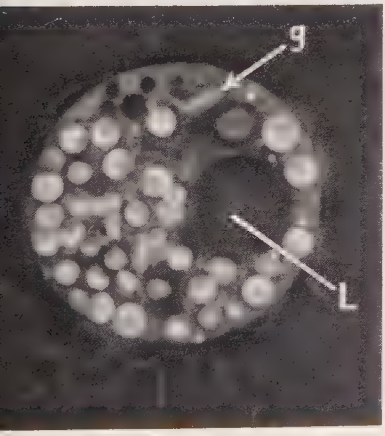
Fig. 22. Section through a Golgi body to show the diagnostic structure; the edge of the nucleus (N) and the cell surface also visible. Micrograph B235, × 45,000.

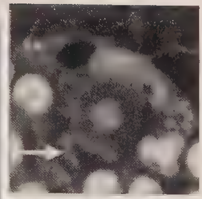
Fig. 23. Section of a Golgi body cut in a plane perpendicular to that of Fig. 22 and showing the cisternae approximately in face view; numerous small thickwalled vesicles, abstricted from the edges of the cisternae, visible loose in the surrounding cytoplasm. Micrograph B1065, × 30,000.

Fig. 24. Part of the edge of the Golgi body of another specimen, cut as in Fig. 23, showing details of the abstriction of small thickwalled vesicles. Micrograph B229, × 30,000.









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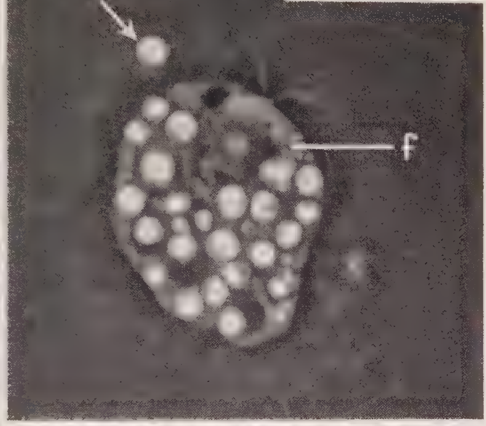

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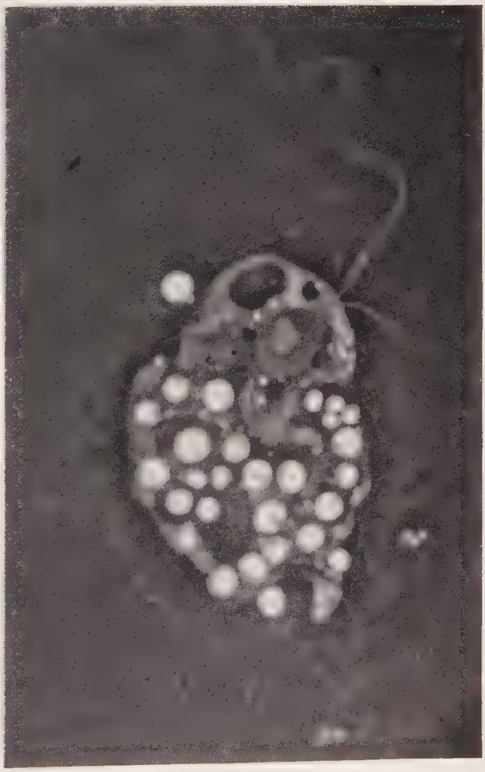

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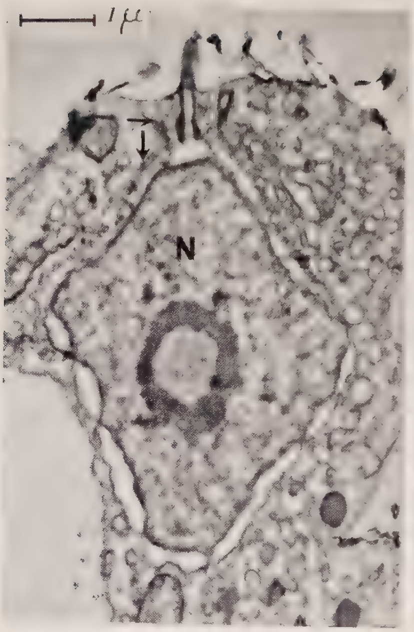
Plate I



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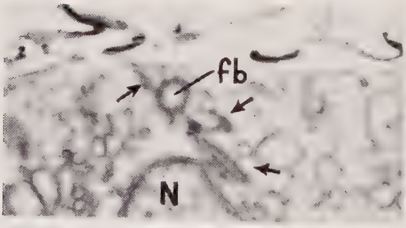

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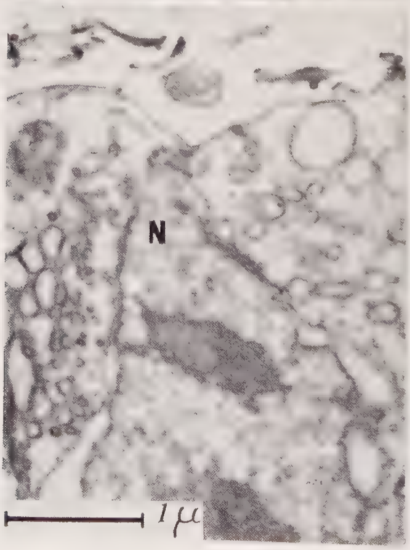

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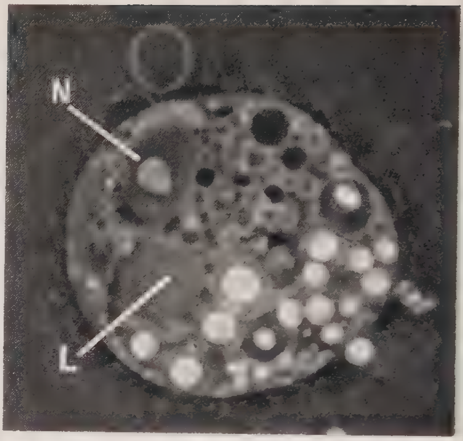

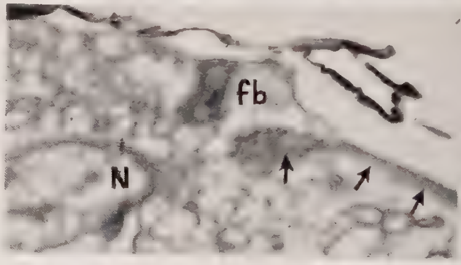

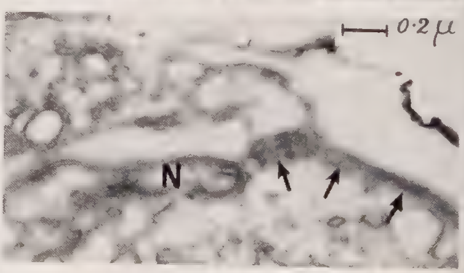

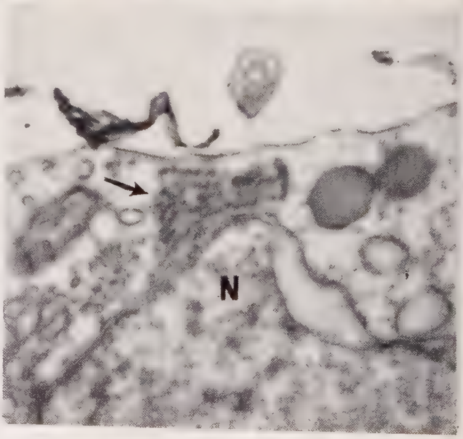

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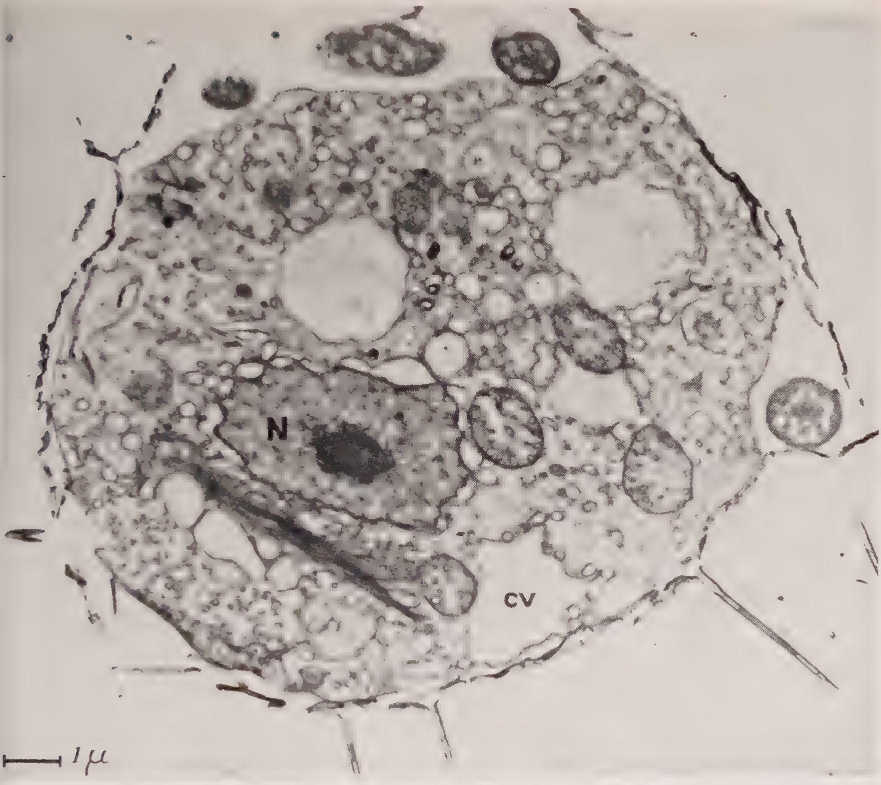

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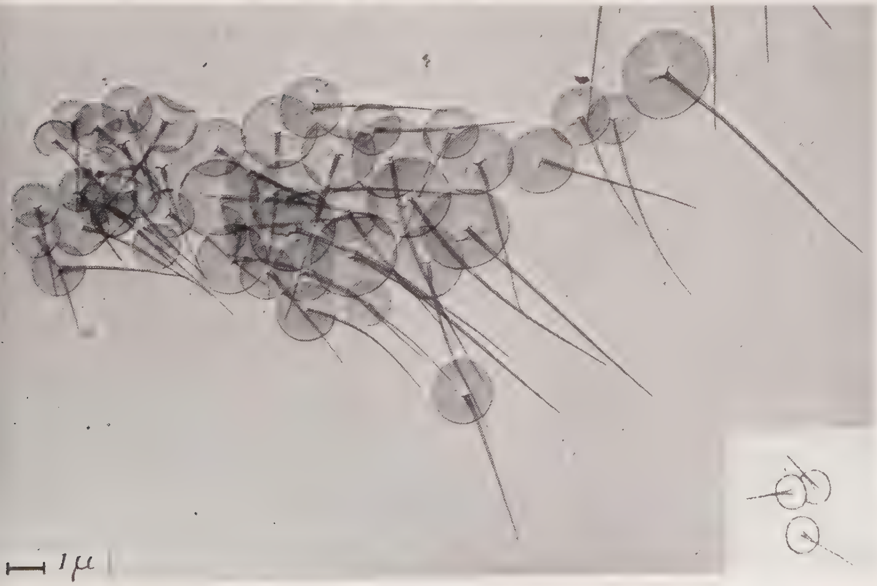

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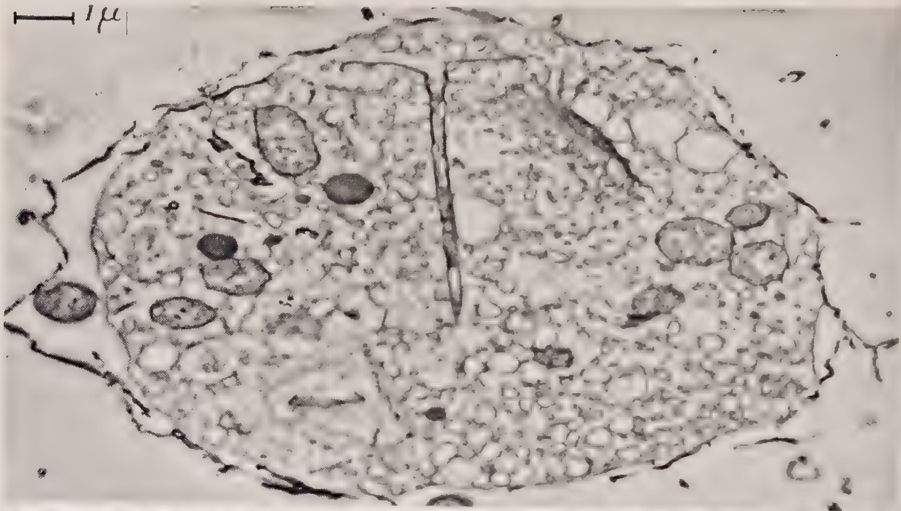

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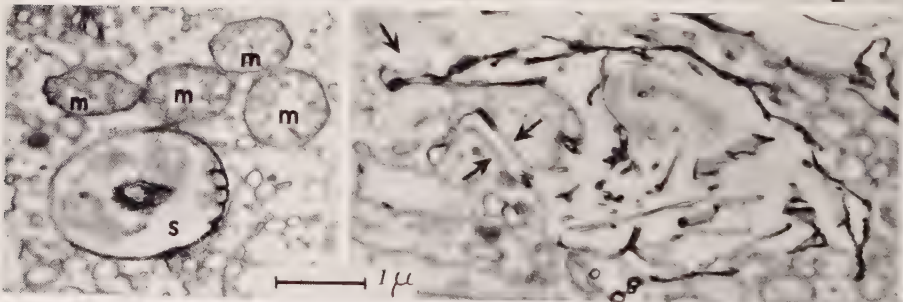

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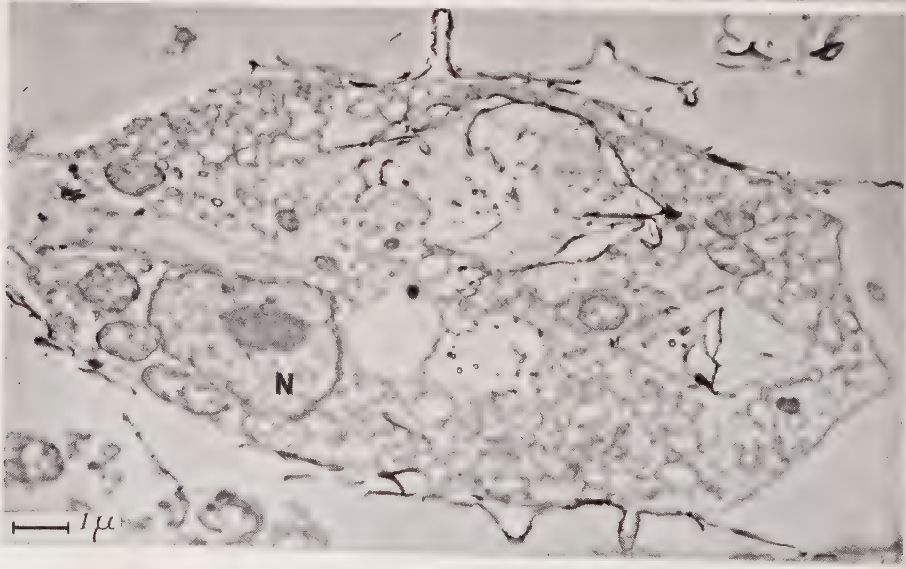

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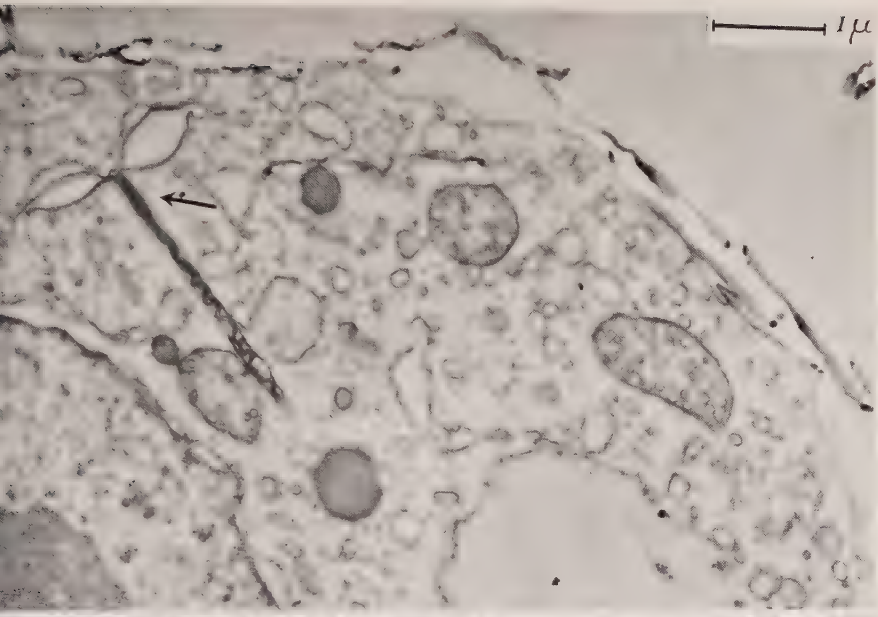
Plate IV



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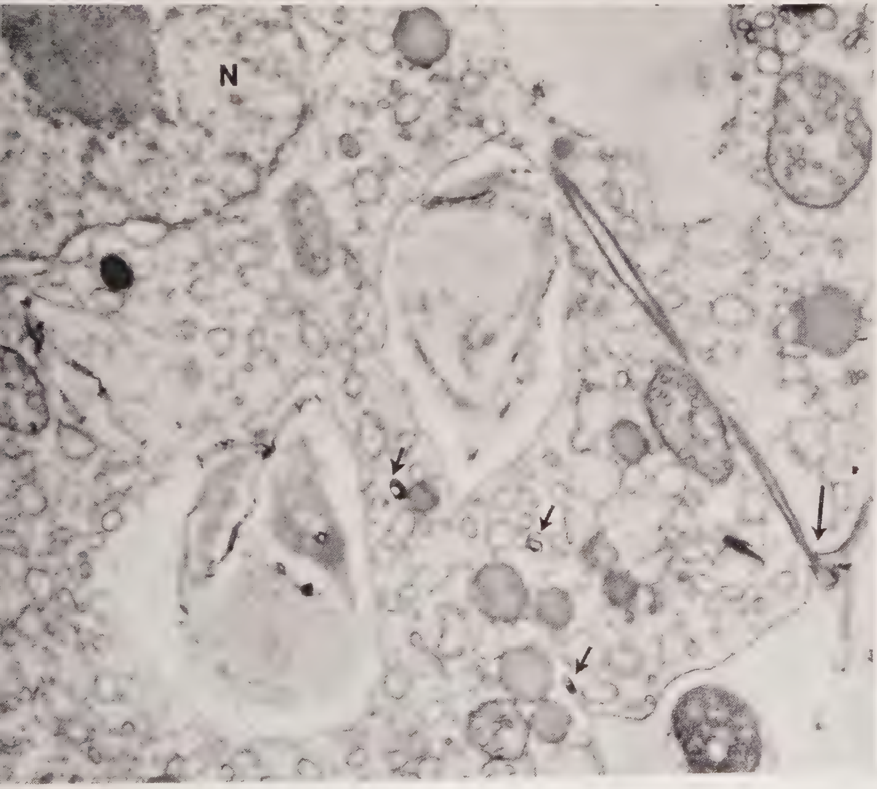

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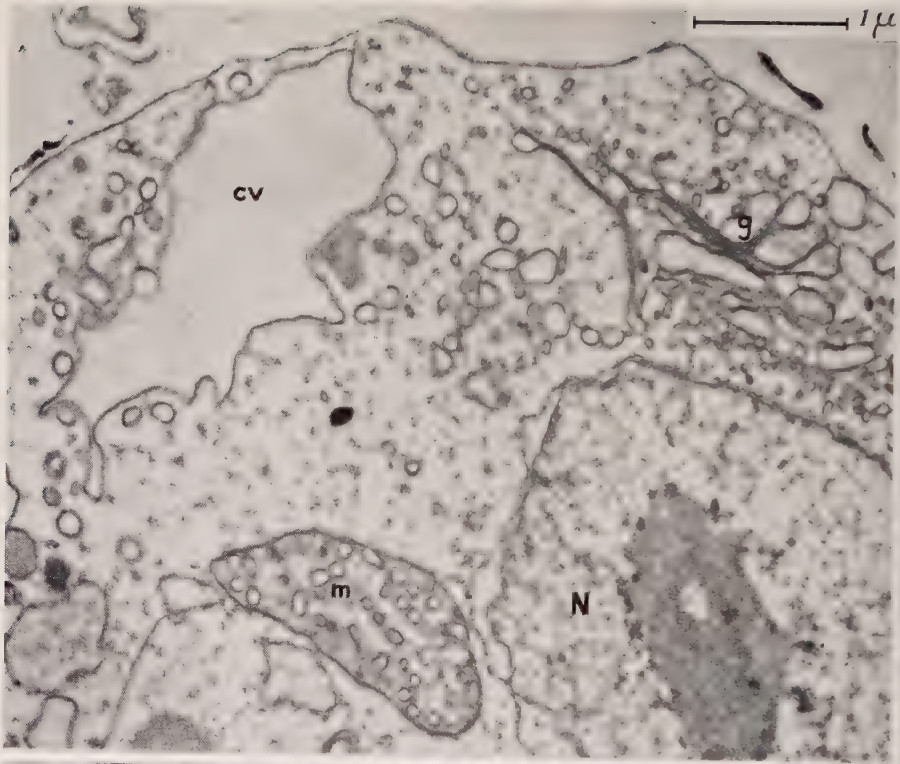

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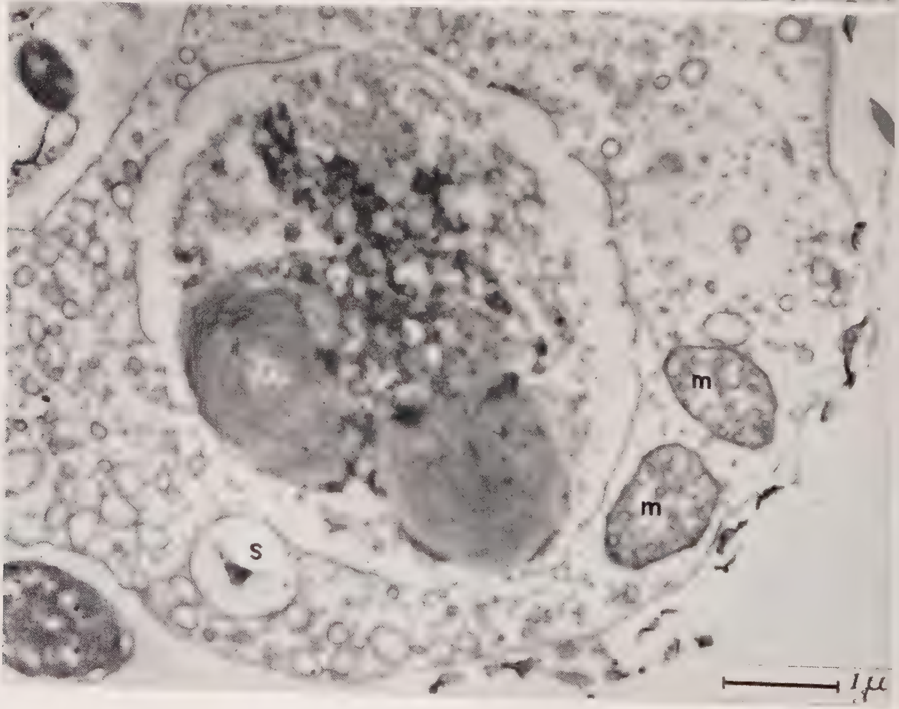

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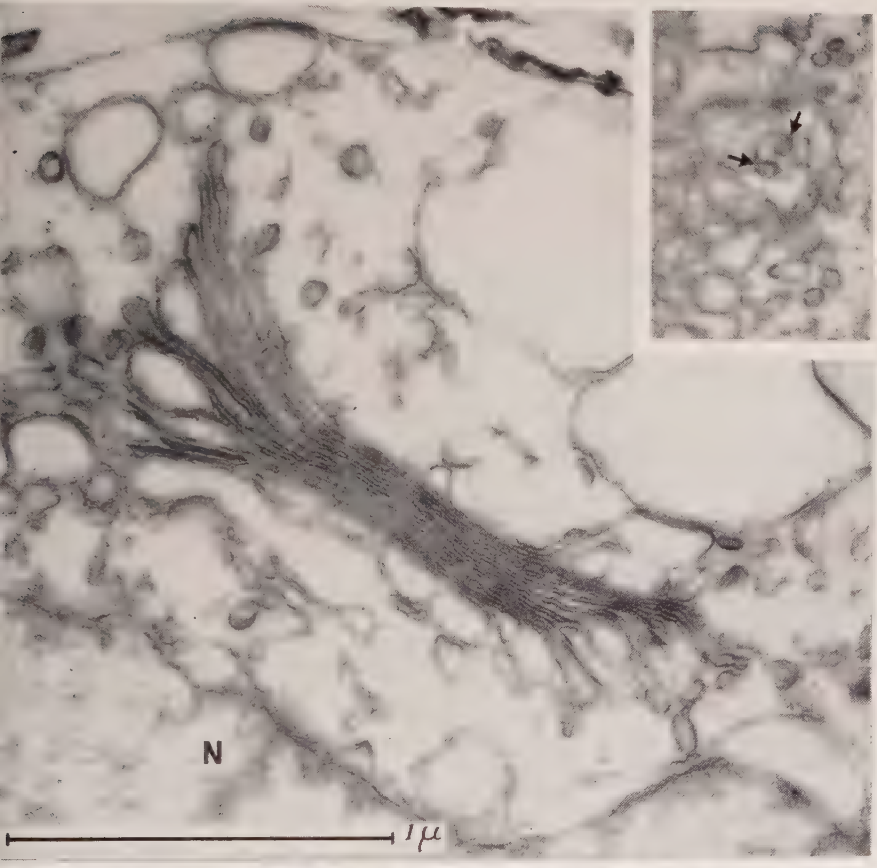
Plate VI



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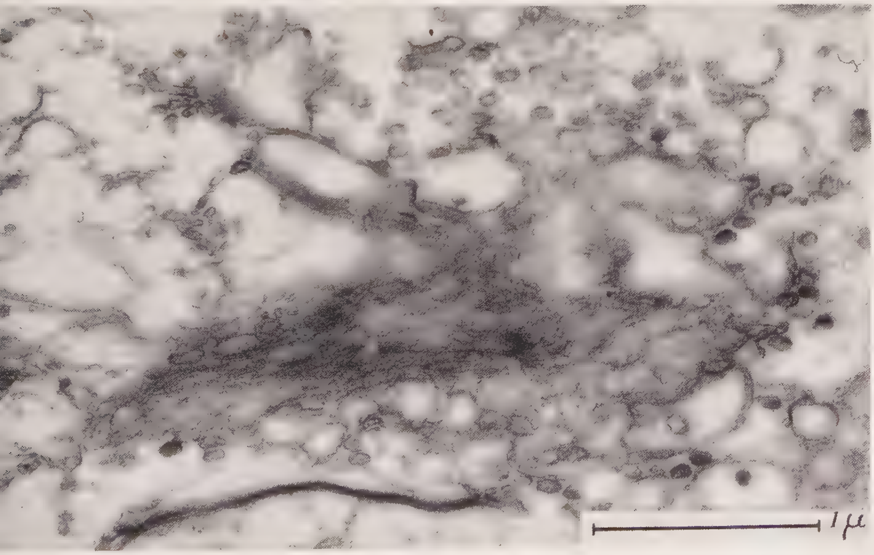

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Plate VII

Announcements

Phycologia

The list of phycological literature appearing during 1959 will be published, at least in part, in the next issue of *Phycologia*. Arrangements have been made to reprint this list on only one side of the page (to facilitate affixing the entries onto cards), assembled into a booklet, which it will be possible to sell to members at a maximum price of $ 1.00. In order to determine the demand for such a booklet, it is necessary that members indicate their interest to the Acting Editor *as soon as possible*.

The International Phycological Society

The first meeting of the International Phycological Society will be held in conjunction with the Fourth International Seaweed Symposium at Biarritz, France, during September 1961 (cf. below). Details of the meeting will be announced later.

Quatrième Congrès International sur les Algues Marines

(IVth International Seaweed Symposium)

Le IV^{e} Congrès International sur les Algues Marines aura lieu à Biarritz (B.-P.) du 18 au 25 septembre 1961. Le Comité d'Organisation a l'honneur de vous inviter à participer à ce congrès qui sera consacré aux aspects biologiques, écologiques, chimiques, techniques et économiques des Algues Marines. Si vous désirez participer à ce Congrès, nous vous demandons de nous le faire connaître au plus tôt.

Le Congrès comprendra:

(1) des séances pleinières avec conférences sur des sujets généraux;
(2) des réunions des deux sections:
  A. Biologie et écologie des Algues Marines;
  B. Biochimie et utilisations industrielles; pour la présentation et la discussion des communications;
(3) des excursions phycologiques dans différents points de la Côte Basque.

Le droit d'inscription est fixé à 45 NF pour les participants et à 15 NF pour les membres accompagnants. Pour tous renseignements complémentaires vous voudrez bien vous adresser à Monsieur BARRIETY, Directeur du Centre Scientifique, Boîte Postale 28, Biarritz (B.-P.), France, ou à M. AD. DAVY DE VIRVILLE, Président du Comité d'Organisation, Laboratoire de Biologie végétale (T.P.), 12 rue Cuvier, Paris 5^e, France.

International Symposium on Marine Microbiology

An international symposium entitled, "Microbial Reactions in Marine Environments," will be held in the Morrison Hotel, Chicago, April 20–24, 1961, under the sponsorship of the Office of Naval Research (U.S.A.) and the Society of American Bacteriologists in cooperation with the American Institute of Biological Sciences. About sixty microbiologists – one half from nations other than the U.S.A. – will present technical papers on such topics as nutritional symbiosis between marine organisms, mineralization activity, and the ecological relationships of plankton. Program chairman is Dr. CARL H. OPPENHEIMER of the University of Texas Institute of Marine Science, Port Aransas, Texas, U.S.A.

Fifth International Congress of Biochemistry

The Fifth International Congress of Biochemistry will convene in Moscow, August 10–16, 1961. Subjects of symposia include evolutionary biochemistry and the mechanism of photosynthesis. The Chairman of the Executive Committee is N. M. SISAKYAN, Lenin Prospect 33, Moscow V-71, U.S.S.R.

Tenth Pacific Science Congress

The Tenth Pacific Science Congress of the Pacific Science Association will be held at the University of Hawaii, Honolulu, August 21 to September 6, 1961, sponsored by the National Academy of Sciences (U.S.A.) and the Bishop Museum, with the cooperation of the University of Hawaii. Among many symposia planned will be one on the algae and their productivity in the Pacific Basin and several in the fields of limnology and biological oceanography. Dr. ROBERT L. USINGER, University of California, Berkeley, is the Organizer of the Section of Biological Sciences.

First International Conference on Protozoology

The First International Conference on Protozoology will be held in Prague, August 22–30, 1961, under the auspices of the Czechoslovak Academy of Sciences.

Information for Contributors

The primary purpose of *Phycologia* is to serve as a clearinghouse for phycological information. Examples of newsworthy items include announcements of meetings and excursions, requests for research or teaching materials, and reports of activities in laboratories and institutions. Members are urged to submit information of this nature. Review articles and brief reports of original research are also welcome. For the present time, at least, papers exceeding 8 printed pages in length will be published only when the author provides substantial financial support.

Contributions should be typewritten, double-spaced throughout. They may be written in English, French, German, Russian, or Spanish. As the use of italics, capital letters etc. is indicated in different ways in different countries, authors are requested to submit their manuscripts without underlinings of any kind. Address all contributions and correspondence concerning editorial matters to the Acting Editor,

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ANDELSBOGTRYKKERIET I ODENSE

March 29, 1961